Spring 3-1966

Volume 77 - Issue 5 - March, 1966

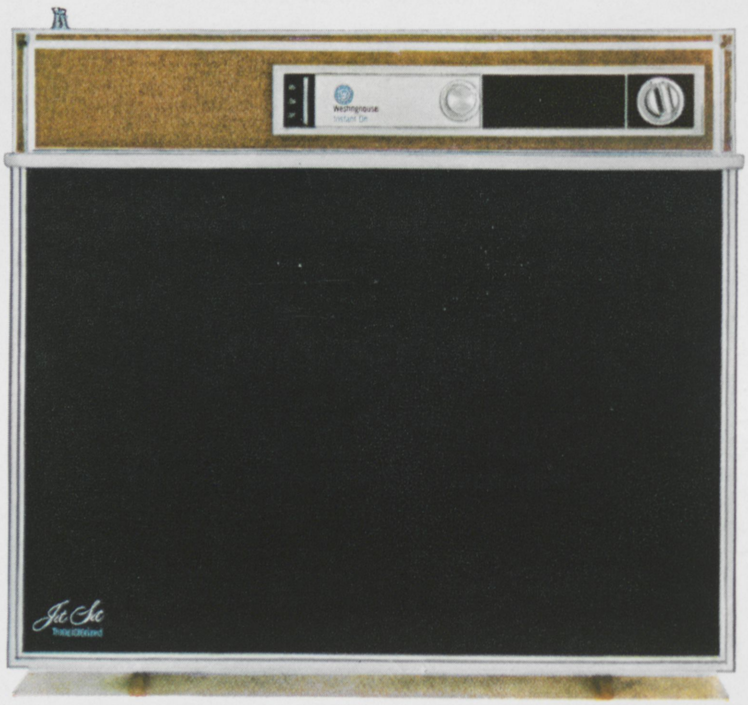
Rose Technic Staff
Rose-Hulman Institute of Technology

Rose Technic

March 1966

- ORIGIN OF THE SOLAR SYSTEM -

New Westinghouse Jet Set gives you a beautiful picture...



even when it's off

The picture tube doesn't stare back at you. And there's no wait for warm-up because it's Instant-On™ television.

Turned on, Jet Set delivers a soft, clear, easy-on-the-eyes picture. New Memory Fine Tuning lets you pre-tune each channel for best picture and sound. Set it once—and forget it.

Turned off, Jet Set doesn't even look like a TV set. But off or on, it's beautiful.

Westinghouse makes a product so you'll enjoy it—any way you look at it.

You can be sure if it's Westinghouse

For information on a career at Westinghouse, an equal opportunity employer, write L. H. Noggle, Westinghouse Educational Center, Pittsburgh, Pa. 15221.

AMERICA'S OLDEST ENGINEERING COLLEGE MAGAZINE IN CONTINUOUS MONTHLY PUBLICATION — 1891-1966

IN THIS ISSUE

COVER NOTE

This month's cover is by freshman Alan Espenlaub. It is his representation of our feature article on the beginning of our solar system.

Volume LXXVII, No. 5

March 1966

Rose Technic

Publisher's Representative
LITTELL-MURRAY-BARNHILL, INC.
369 Lexington Avenue,
N. Y. 17, N. Y.
and 737 N. Michigan Avenue,
Chicago 11, Illinois

ECMA Chairman
PROF. J. R. BISSETT
Civil Engineering Department
University of Arkansas
Fayetteville, Arkansas

PRINTED BY MOORE-LANGEN PRINTING AND PUBLISHING CO.
140 North Sixth Street, Terre Haute, Ind.

Published monthly except June, July, August, September and January by the Students of Rose Polytechnic Institute. Subscriptions obtainable by a $3.00 donation to the Student Activities Fund of Rose Polytechnic Institute. Address all communications to the ROSE TECHNIC, Rose Polytechnic Institute, Terre Haute, Indiana.

Entered in the Post-office at Terre Haute as second-class matter, as a monthly during the school year, under the act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized December 13, 1918. This magazine does not necessarily agree with the opinions expressed by its contributors.

ROSE

ROSE POLYTECHNIC INSTITUTE

TERRE HAUTE, INDIANA

HIGH SCHOOL GRADUATES OF 1966

You are cordially invited to visit Rose Polytechnic Institute where you can earn a degree in:

CHEMICAL ENGINEERING

ELECTRICAL ENGINEERING

MECHANICAL ENGINEERING

CIVIL ENGINEERING

MATHEMATICS

PHYSICS

CHEMISTRY

Office OF ADMISSIONS

ROSE POLYTECHNIC
INSTITUTE
TERRE HAUTE, INDIANA

GUEST EDITORIAL

RIGHT, GOOD BAD, EVIL

by Prof. John G. Biel

The basic and central problem of ethics is simple to state: what action is right action? The difficulty is over the "standards"—and, sometimes, it seems all Man's efforts, over the centuries, to reach some settled and reasonable view about *what* is good or bad, right or wrong, have been doomed to failure.

Someone once said that we are, today, "hell-bent for Hades in a hack"—that nothing at all can be done to stop us; that Man, as an individual, is no longer able to shape his own destiny.

That time has not quite arrived. We still have time—and the opportunity—to change our destiny but to do so, as one commentator has said: " . . . we must effect some drastic changes—changes in our behavior patterns, changes in our though processes, changes in our moral values."

Plato, in the opening sections of his *Republic,* claims that "right" is nothing but the interest of the stronger. We know that Plato was interpreting "stronger", then, as "rulers" but, extrapolating that statement to today, how can we interpret it in some context having a real and significant meaning to contemporary life?

Just what is "stronger?" It seems to be something —or someone—who has more strength, or more vigor, or more force, or more potency, or more effectiveness, or more endurance, than someone—or something—else.

Now—who or what fits that interpretation, today? No one—and nothing—except the youth of our society! It is they—and they, alone— who will be projected into the future. It is on them—and on them, alone— that whatever destiny our culture may have in the future will rest. Any "changes" in our behavior patterns, our thought processes or our moral values depends entirely upon them. Our "strength" lies in them —the "stronger" of today.

So—what should be the standards of ethical values, today? I propose that this approach be considered seriously—that anything "right" for the youth of today is "good" and anything "bad" for our youth, today, is "evil." Anything which will promote the interests of the youth of today will be a "good" for society as a whole. To this end, the presently accepted conventions and mores of our society—where such conventions and mores conflict or are logically inconsistent—should give way. Morality must need be viewed according to this approach for it is only in the youth of today that the needed, necessary and desirable changes in our behavior patterns, our thought processes and our moral values can—or will—be made; it is in these changes that our future destiny lies.

It is the serious and aweful obligation and duty of the older generation, alive today, to train, guide and mold that youth; but, in doing so, to see to it that no course of action is pursued which does not have as its ultimate aim and objective the interests of that youth. No course of action—whether economic, political or social—should be adopted or perpetuated by these "old men" which is not "good" for this group of "stronger." But perish the thought that this approach is entriely pragmatic or hedonistic!

In the words of an anonymous writer:

Let yourself rub off on him.
Let him sit beside you as you work,
To work with you,
To study with you,
To be perplexed with you,
To analyze with you,
And to dream with you.
Give him the impossible task to do,
The Unanswerable question to answer.
There is no better way to train—
Whether you be Socrates training Athenian youth
Or an American man of business
Teaching some hopeful the craft of management
In mid-century industrial America.

PLATONIC AND ARISTOTELIAN QUISA

Tony Tietz is a freshman from Cathedral High School in Indianapolis. He is active as a varsity football player and as a member of the Glee Club. He is also a pledge of Lambda Chi Alpha Fraternity.

by

ANTHONY TIETZ

Throughout the ages man has continually wondered about the world around him. He has enjoyed magnificent success in the field of science, but some questions of a philosophical nature remain as uncertain as in ancient times. Perhaps the most important of all these questions concerns the nature of being. What is *reality*? What is existence?

Probably no two men have made a greater contribution to thought on these questions than Plato and Aristotle, the masters of Greek philosophy. This article will attempt to present the basic ideas of these two philosophers about reality. It would be difficult, practically impossible, in fact, to define the meaning of the terms reality and existence before proceeding directly to the Platonic and Aristotelian views. It is the uncertainty concerning these terms that is to be discussed. A vague idea of *reality* is sufficient.

After a moderate amount of reading, it soon becomes evident that Plato and Aristotle agreed on many points in their personal ideas on reality. Let us consider these common ideas since they are the basis of both Platonic and Aristotelian philosophy.

COMMON POINTS OF AGREEMENT

Plato and Aristotle explained the reality of their surroundings as a combination of matter and form. An object such as a table consisted of the matter composing it and the form imposed on the matter. Both are vital to the existence of that table. The matter could exist in infinite patterns, but it cannot exist as a table until the form of a table is imposed on it. But the form of a table lacks physical existence until the matter is provided.

Aristotle developed a four-step basis of causality in Book II of *Physics* to explain the existence of everything in the natural universe. It is basically in agreement with Plato's views, so it can be considered as common view of both. The four causes are material, formal, efficient, and final cause.

The material cause is simply the matter involved. The formal cause of a natural body is the plan or form imposed on the matter. The efficient cause is the force that acts upon the matter to impose the form. Finally there is a purpose or end sought by the efficient cause, and this end is the final cause.

A discussion of causality would not be complete without some mention of the fifth cause. Aristotle's fifth cause is the prime mover, from which all other cause derive their source. However, both Aristotle and Plato agree that it is impossible to know anything about this prime mover; so they diverted their energies to other problems.

Although matter and form are both essential to the existence of a natural body, form is the most important because we can only know things by their form.

> The form supplies the sole ground for the explanation and understanding of whatever can be understood or explained about a thing. But what is most known

(*Continued on page* 14)

If I join the Timken Company after graduation, what will they do for me?

Every man with any job hunting experience knows not to ask that question.

And yet, we think it has some validity. After all, a man's growth can depend as much on the company he works for as the company's growth depends on the man (remember, there are no statues to committees).

So to invest in your growth, and ours, every young graduate engineer who joins the Timken Company spends up to four years in one of 22 individualized training programs.

Extensive training

Instruction takes place on the job and in the classroom. Later on there are executive development programs at leading universities.

But don't misunderstand us. The Timken Company is not a graduate school. With us, you earn as you learn.

As one of our engineers, you'll learn much of what we know about tapered roller bearings, or fine alloy steel, and their infinite applications. Hopefully, you'll teach us something, too.

You can be an indoor-type working on straight application engineering, research, testing and production. Or you can be an indoor-outdoor-type and work in sales engineering. It doesn't matter—choice of assignment is up to you.

Challenging assignments

If you choose the latter group, you'll work in automotive, industrial, and railway bearing sales—or steel sales—helping customers solve *their* engineering problems, which are also *ours*.

Some of our recent efforts: bearing engineering for a telephone cable-laying ship now crossing the Pacific, the Alweg Monorail, the world's tallest crane and biggest strip mining shovel, Craig Breedlove's Spirit of America, a moveable grandstand for the new District of Columbia stadium. Steel problem solving for Atlas missile silos, Project Mohole, the latest Kaman Helicopters, a 400-foot crane boom and hundreds of automotive gear and die applications.

We won't forget you

Advancement is not restricted to one department or division. A steel sales engineer may be transferred to automotive sales and from there to International. Whatever your job, we'll never forget where we've put you. This is one of the advantages of working for a company that is the world's largest producer of tapered roller bearings and a foremost producer of seamless steel tubing, but is not the world's *largest* corporation. We employ about 20,000.

The Timken Company has three products: Bearings, Steel, Rock Bits. Uses for these products number in the growing thousands. And there is always something new stirring.

The dramatic switch of the nation's railroad freight cars to roller bearings, a field we pioneered, is an example.

An international company

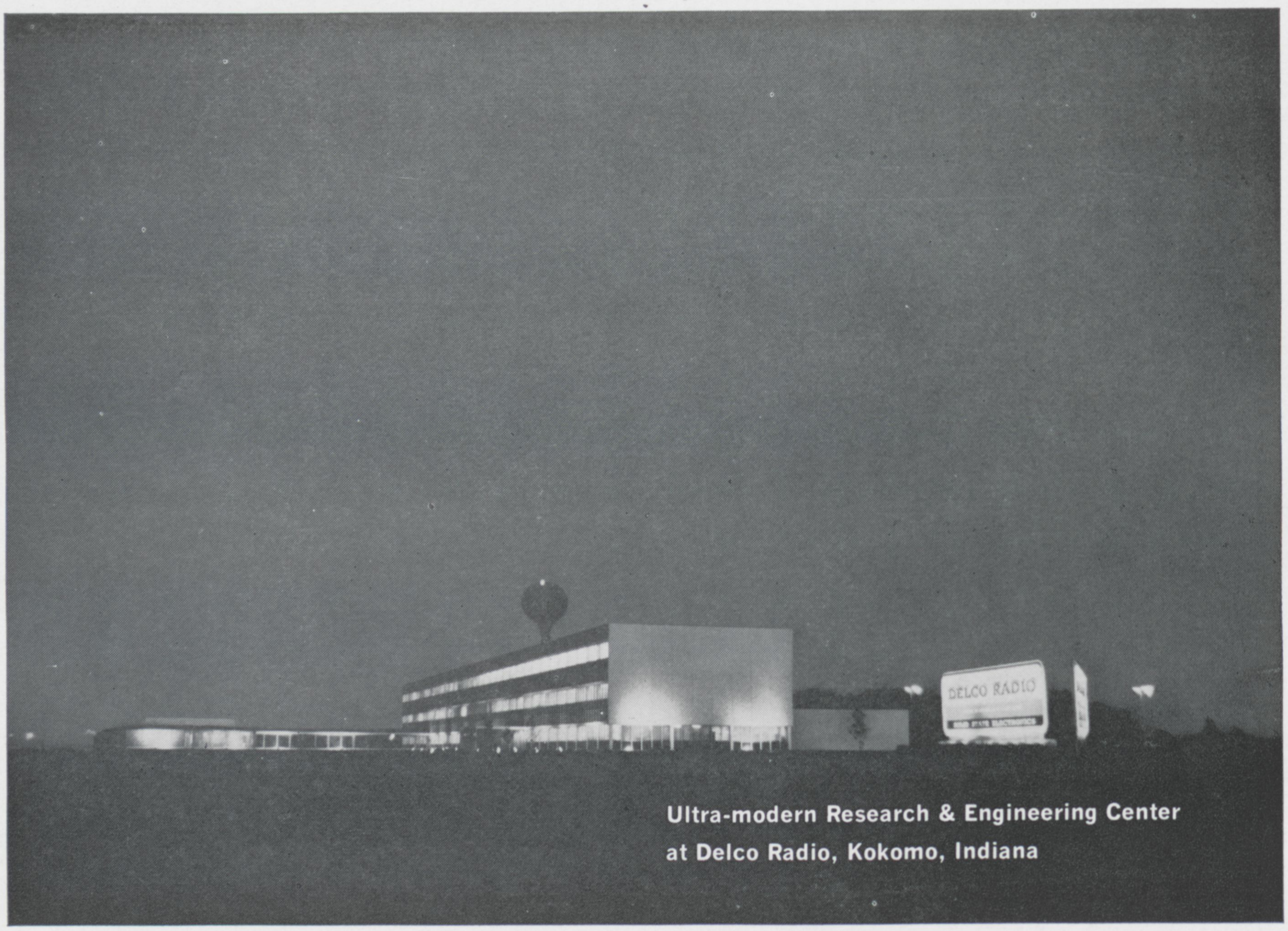
There are 31 Timken Company sales offices in the United States and Canada. Practically every major city has one.

We serve markets in 119 countries from 14 manufacturing plants located in Australia, Brazil, Canada, England, France, South Africa and the U.S. And we're still growing strong.

If you are, too, we'd like to hear from you. Write to Department MC for Career booklet.

An equal opportunity employer.

The Timken Roller Bearing Company  **Canton, Ohio 44706**



Ultra-modern Research & Engineering Center at Delco Radio, Kokomo, Indiana

To Continue To Learn And Grow . . .

. . . is a basic management philosophy at Delco Radio Division, General Motors Corporation. Since its inception in 1936, Delco Radio has continually expanded and improved its managerial skills, research facilities, and scientific and engineering team.

At Delco Radio, the college graduate is encouraged to maintain and broaden his knowledge and skills through continued education. Toward this purpose, Delco maintains a Tuition Refund Program. Designed to fit the individual, the plan makes it possible for an eligible employee to be reimbursed for tuition costs of spare time courses studied at the university or college level. Both Indiana University and Purdue University offer educational programs in Kokomo. In-plant graduate training programs are maintained through the off-campus facilities of Purdue University and available to employes through the popular Tuition Refund Program.

College graduates will find exciting and challenging programs in the development of germanium and silicon devices, ferrites, solid state diffusion, creative packaging of semiconductor products, development of laboratory equipment, reliability techniques, and applications and manufacturing engineering.

If your interests and qualifications lie in any of these areas, you're invited to write for our brochure detailing the opportunities to share in forging the future of electronics with this outstanding Delco-GM team. Watch for Delco interview dates on your campus, or write to Mr. C. D. Longshore, Dept. 135A, Delco Radio Division, General Motors Corporation, Kokomo, Indiana.

An equal opportunity employer

solid state electronics

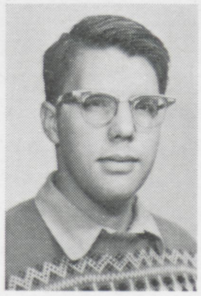
DELCO RADIO DIVISION OF GENERAL MOTORS

KOKOMO, INDIANA

THE INTERIOR OF THE EARTH

by

KIM DAVID SAUNDERS



The author of this article is Kim Saunders, junior math major. He comes from Homewood, Ill. He is a member of the math club, Tau Beta Pi and Pi Mu Epsilon.

METHODS OF STUDY:

The earth is about eight thousand miles thick. Of this man has been able to penetrate only to about a depth of five or six miles directly. As a consequence, all the information pertaining to the central structure of the earth must have been obtained through inference from data obtained on the surface. In a way, then, our model of the earth is a function of the instruments used and the thinking behind the inferences. With this in mind, it might be well to take a brief look at some of the instruments typical of this science.

One quantity used in the study of the earth is the geopotential surface. This is a surface of constant acceleration. It is every where perpendicular to the direction of the acceleration due to the combined effects of gravitation and rotation of the earth. Actually, there are an infinite number of these, corresponding to the different values the gravitational force may assume.

These surfaces are determined by either plotting from the direction of the field or by actually measuring the field at a great number of places over the surface of the earth. In order to measure the strength of the field, the usual method is to measure the period of a pendulum of standard dimensions, and reducing this to the actual value of g at the point under consideration. These are then plotted on a world map and the slope of the surfaces is determined by the spacing of the geopotential lines.

Another way of calculating the geopotential surfaces is the determination of the gravitational field from the errors in the motion of artificial satelites with respect to the theoretical motion they would have if the earth was a homogenous spheroid.

Another quantity which is valuable in producing inferable information is ensemble of the records of various seismic events. The events may be of a natural or man made nature. The natural event is usually an earthquake, while the man-made event is usually some kind of explosion. The seismic events are always characterised by a production of waves of the earth.

Two types of waves are produced in a solid elastic medium (assuming the medium is isotropic and the waves are being considered as plane over a small surface.) These are compressional and shear waves. The compressional waves travel with a velocity of:

$$v_c = \sqrt{\{K + \frac{4}{3} u\}/p} \qquad 1.1$$

where K is the bulk modulus and μ is the shear modulus)

and the transverse or shear waves with a velocity of:

$$v_s = \sqrt{\mu/p} \qquad 1.2$$

As the compressional wave has a higher velocity, it will arrive before the transverse wave. For this reason, it is called the primary wave, and the shear wave is called the secondary wave. They are denoted P and S respectively. From the results of measuring the times of travel from a shock, a number of things can be determined. Among these are the velocity at different depths of each of the types of waves and then the relation between the bulk modulus, shear modulus and density.

The idea behind this is very simple. It may be expressed graphically, as in figure 1. When the results of the times of arrivals are plotted against the distance from the focus for a number of stations, there will usually be a number of times the same wave reaches the station. This shows up as a number of points on the diagram. In the example shown, only two points per station were allowed. These, of course represent the times taken along different paths.

From the slope of the graph, the velocity along each path may be determined, (usually by a least squares method), and the depths of the layers determined by a combination of the intercepts on the time axis and the velocities. This is the idea, but it is not quite so easy in practice as the layers are not planar, but are usually concentric spheres. Also, in homogeneous layers, the density does not remain constant, but increases as a function of the pressure. This plus the fact that the bulk and shear moduli are also function of the pressure leads to complications.

The method of resolving some of these complications today seems to be that of choosing some model of the earth and seeing if the data observed fits the model. If it does fit, and the model can be used to predict some other expected data and this fits, then the model is considered an acceptable representation of the earth until some data is found that is not explained by this theory.

This will be taken up later. There are other quantities that aid in the construction of the models of our planet. One related to the seismic studies is the study of the free oscillations of the earth. The object of this study is to determine the major modes of vibration of the earth and the contribution each makes to the total. The composition of the vibrations, being a function of the structure then gives additional data to be tested when a proposed structural theory is to be tested. The data from the free oscillations is recorded by any of a number of different types of very sensitive strain gauges.

Heat flow is yet another quantity that must be explained by any comprehensive theory of the earth. This includes the explanation of the variations, the actual value of the rate and the past history of the heat flow. Also, in connection with this must be explained the action of vulcanism. Almost all the theories have the heat flow portion of the theory in accordance with each other.

In direct contrast to this is the theory of the magnetic field of the earth. Different theories disagree. A good reason is that none of the theories can explain adequately, the production of the magnetic field and the variances in time and space from an almost uniform field. The measurements of this quantity are usually done with airborne or rocket borne magnetometers. The results of these measurements are analysed in much the same way as are those connected with the study of the geopotential field.

The last form of data to be considered is that consisting of astronomical information. This includes the tides, nutation of the earth, precession of the equinoxes and any other effects which can be of use in studying the irregularities in the composition of the earth.

PRESENT THEORY OF THE EARTH'S STRUCTURE

It is assumed at present that the earth is divided into about four major regions: the crust, the mantle, the outer core and the inner core, (see figure 2). In general the crust is the place where there are major geological event occurring. It seems to be the place of greatest inhomogeneity. Directly below the crust is the mantle. The upper part of the mantle is thought to be in tension while the area above it is probably in compression (2) (see figure 3). The rest of the interior seems to be in rather static equilibrium with little or no inhomogeneity (2).

The evidence for these divisions is somewhat overwhelming if all of it is presented. Some of the major reasons are as follows: The density of the earth as determined from astronomical measurements is greater than that expected if the earth were composed of material similar to that on the surface. This includes taking the increase in density with the pressure into account. Thus, the earth must be composed of some

(*Continued on page* 30)

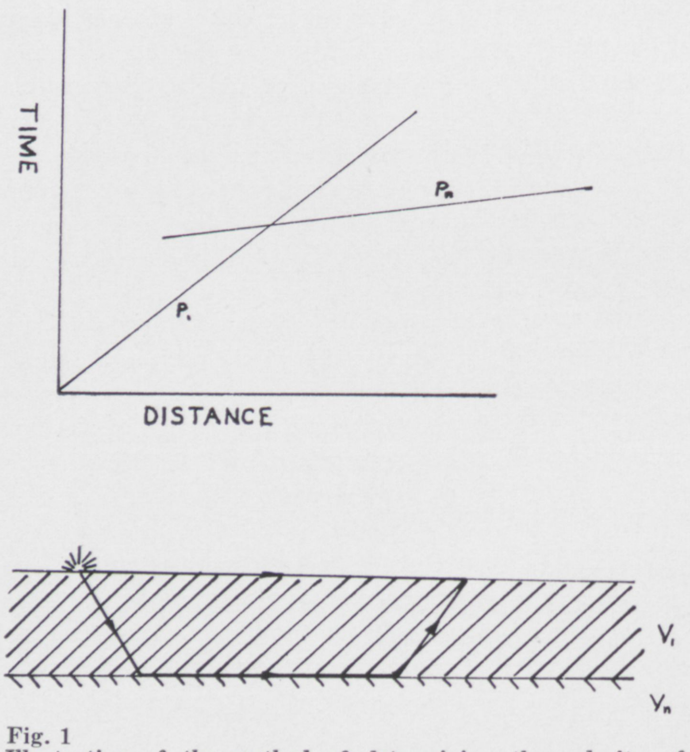


Fig. 1
Illustration of the method of determining the velocity of waves in different layers of the earth. The slopes of the graphs give the velocities and these combined with the intercepts on the T axis give the depth of the discontinuity. (Kuiper p. 86)

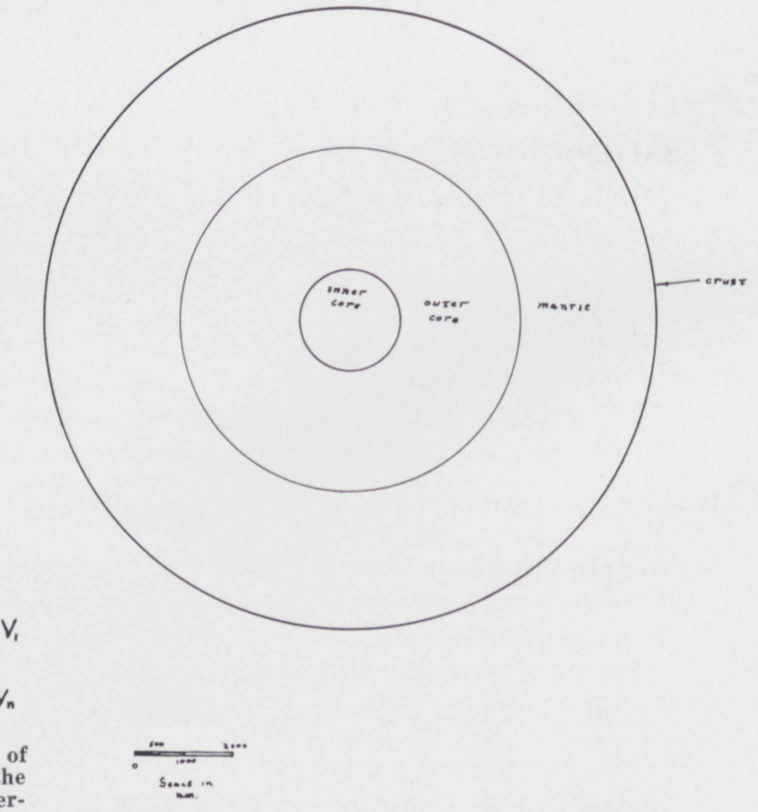


Fig. 2

Diagrammatic Structure of the Earth.

THE ORIGINS OF THE SOLAR SYSTEM

by GARY RANSFORD

The author of this article is Gary Ransford. Gary is a Physics major and is in his senior year at Rose. He is also a member of the American Institute of Physics.

In discovering the process by which the solar system came into being the scientists have not been so successful. The prevalent theories all do a fair job but none of them has found the distinction of being the correct theory. By the term "correct" it is meant that none of these account exactly with no modifications for the phenomena of which we are part.

However, we must appreciate the difficulty of the problem which presents itself in the attempt to discover the origin of the solar system. We might liken ourselves to a cell on a feather in the wing of a chicken and we are making an attempt to discover the origin of the feather on which we are a resident. The problem increases in complexity the farther we delve into it. Of course, there is a solution to the problem, but it is exceedingly confounding to approach. This is the situation in cosmogony, as the study of the evolution of the universe is called.

The physicists of the past have approached the problem in two main directions. One of these called for the interaction with our sun (then much larger than now) with some other object in the universe(star, gas cloud, etc.) The second approach was one which presented the idea of an internal evolutionary process which caused the sun to shrink to its normal size and the planets to be condensed out.

The proponents of both ideas have interpreted the facts of the experiments on the solar system to refute each other's theories. The fact is that both types of theories are on shaky footing and often times they resort to a type of magic.

The theories of cosmogony, obviously, cannot be influenced by the will of one man. But they are based on a theory which has been shown to be incorrect because of the interaction between the observer and the object. But even the theory which does describe the interaction between the observer and object has been shown to be incorrect when it is extrapolated to cosmical scale. Whenever a theory which can weld relativity, quantum theory and newtonian mechanics of science together into a rational whole is presented, then possibly this will serve as a basis to a correct theory of cosmogony.

Evolution Theories:

The first theories to be discussed are the nebular type theories put forth by Kant and Leplace.[1] This theory postulated the breaking up of the sun, then much larger than it is now, by shrinkage and shedding of matter in its equitorical plane. Here the mass of the solar system is concentrated near its center, hence the total angular momentum of the sys tem is very small. However, despite this smallness of angular momentum, the sun could have undergone this change if the mass was sufficiently concentrated.

The mass begins to break up in this fashion that we have related when

(1) $\dfrac{w^2}{2\pi\delta p} = 0.36$ where ρ is the mean density

If r_o is the mean radius, k the radius of gyration, m the mass, and L the total angular momentum of the sun before beginning to break up, then

(2) $M = \dfrac{4}{3}\pi p r_o^3$ and

(3) $L = mk^2 w$ This gives us that

(4) $\dfrac{w^2}{2\pi\delta p} = \dfrac{2L^2 ro^3}{3\delta m^3 k^4} = 0.36$

If we estimate the age of the earth as 5000 million years, we find that the sun must have been close to its present state. The mass of the sun, at that time, must have been almost equal to the total mass of the solar system today, i.e., 2×10^{33} gms, and its angular momentum almost equal to the present total angular momentum of the solar system. This total is due mainly too the planets Jupiter and Saturn, and its value in CGS units is about 3.3×10^{50}. If we plug

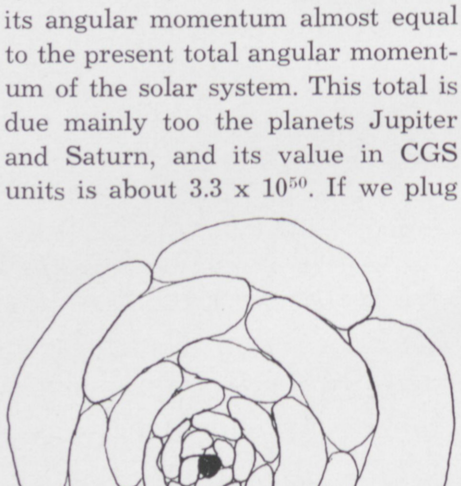


Fig. 1. "Bean-shaped" Eddies.

in the values we have received here into equation (4) we obtain the value,

$$(5)\quad \frac{k^4}{r_o^3} = 3.7\text{x}10^8$$ Now calling r_o equal to the present sun's radius we get the value for:

$$(6)\quad \frac{k^2}{r_o^2} = 0.072$$ For a homogenous mass, having the shape of a Roche's critical lens-shaped figure, the value of k^2/r_o^2 is 0.523. So we can rewrite the equation (6) by making the following assumptions. If we call x as equal to the fraction of the total mass of the primordial sun concentrated at the center of the critical lens-shaped figure the fraction (1-x) of the mass is uniformly spread throughout the volume. The equation (6) becomes

$$(7)\quad \frac{k^2}{r_o^2} = 0.523\ (1—x) = 0.072.$$

This gives that this condition will hold whenever x = 0.863. Thus the present angular momentum of the solar system would be sufficient to break up the sun if 86.3 percent of the mass is concentrated in the center of the figure while the remaining 13.7 percent is distributed throughout the critical lens-shaped volume of Roche.

The sun's density must decrease continuously as one passes from the center toward the border, the result above shows that if the sun did break up due to excessive rotation the density near the edge is less that 13 percent.

Poincare has shown that if this shedding of matter does take place in the ringlike manner as theorized above it will scatter into space under the disruptive effects of its own rotation unless the mean density is more than 0.36 times that of the main mass.

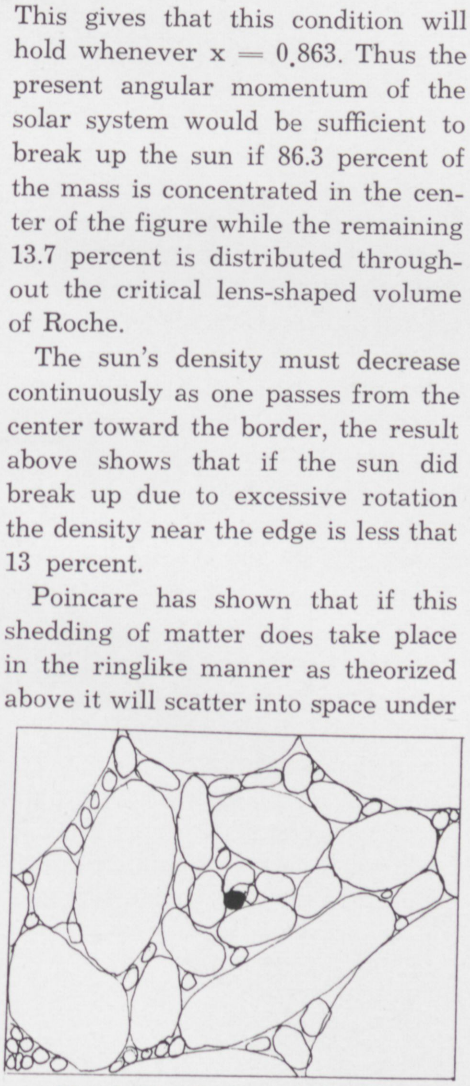


Fig. 2. Distribution of Kuiper.

So if the sun did shed rings, these rings could form planets only if the matter in the rings immediately condensed to about three times its original density. The ring of mass would be rotating with the sun and, due to its smallness of mass, would have no gravitational cohesion. Instead of increasing in density the matter would scatter under its own internal gaseous pressure. Thus it appears doubtful that this ring could even double its density before the disrcptive rotational influence would present itself.

The principal objections to this theory, however, are of a more direct and philosophical form. If the sun was once lenticular in shape and was capable of shedding matter by rotation, it is difficult to see how it could become spherical as it is today.

Another failure of this theory is in the explanation of the formation of the satellites of the various planets. Some are so small that they can only have escaped scattering into space by liquifying or solidifying immediately after birth. Thus their conception could not have been a lengthy process, but must have taken place very rapidly.[2]

A third objection which weighs heavily upon the abandonment of this theory is the distribution of angular momentum in the solar system. The sun possesses nearly 99 percent of the mass but barely 2 percent of the angular momentum. When these requirements are applied quantitatively to the sun we find that it could never have been moving fast enough to give off matter rings.[3]

WEIZSACKER'S THEORY

And so this view of internal evolution of the solar system seems doomed from its conception. But it in the 1940's C.E. von Weizsacker brought forth a theory based on the same idea, ie., the idea of the planets being born in a closed system, without outside interference.

He began by stating that the overall dimensions of the planetary gas cloud are interpreted on the basis of the properties of the gas cloud from which the galaxy is formed. By necessity the gas cloud was in turbulent motion and the random velocities of the turbulent elements could be assumed to be around 20 Km/sec.

The size of the eddies must have been, at the smallest, larger than the mean free path of the atoms. When the calculations to find this are performed the mean free path turns out to be about 7AU or 10^{14}cm. Collisions between eddies caused them to obtain angular momentum. The outer portions of the eddies received rotational velocities comparable to the mean relative velocities of the eddies. By this method we can find the size of the original eddy which formed the solar system. The crux of the argument can be stated: If the orbital velocities of the planets are equal to the relative stellar velocities, the system is stable only if the solar system has its present size.

The solar nebula could have been formed by two processes: (1) by being an independent eddy captured by the solar eddy. Regardless of its origin it must have been of greater mass density than the galactic cloud from which it was formed.

If the mass of the nebula itself (minus the solar mass) is assumed to be 0.1$\bigcirc$ and we assume the size to be approximately equal to the size of the present solar system coupled with an assumption of the vertical thickness being one-fifteenth of the extent of the system (this is suggested by the present orbital inclinations) we get for the mean density the figure of 10^{14} atoms per cm^3. The mean free path from this turns out to be only a few centimeters.

The size of the eddies inside the nebula will be greatly reduced. Their turbulent pattern will no longer be completely random as the force of gravity greatly predominates over the gradient of gas pressure and the turbulent viscosity. The portions of the nebula will be in rotation around the sun in the forms of Kepler mo-

(*Continued on page 32*)

PLATO (*Continued from page* 6)

is most real. Therefore the primary reality is Forms, and any reality of lower degree is necessarily dependent on them.[1]

This explanation of reality seems direct enough, but it does not encompass all of Plato and Aristotle's views on reality. This applies to existence in the Natural World. Both of these men also believed in the existence of ideas or universals. Their relative views on this type of existence have a basis of development also.

This might be explained through the process of abstraction. By examining particulars in the natural world of motion and flux, we can observe similarities and tend to classify similarities and tend to classify similarilarities with more or less abstract *ideas*. From observing many objects that we sit upon, we approach the *idea* of a perfect chair. Since no two chairs are exactly alike, no one chair-like object can possess the total essence of being a chair. The idea or form of chair is removed from matter.

Universals and forms are the basis of knowledge — without them we could know nothing. But are they in fact more important than the natural world of particulars? Or rather, do they possess a higher reality than the natural world? Here Plato and Aristotle part in their views. Plato answers these questions positively, but Aristotle disagrees completely.

THE CONCEPT OF IDEAS

Let us first look at the Platonic concept of *ideas*. Plato would have us consider . . .

> an ideal world containing eternal and perfect prototypes of the natural world. Whatever of quasi-existence our changing world possesses, it owes to an imperfect participation in the full and perfect existence of the other.[2]

The particular characteristics in the natural world are inherently imperfect. Plato's ideas here are somewhat similar to those of Parmenides, that "what is real should be eternal and unmoved."[3]

Plato explains this belief in Book V of *The Republic*. To Plato,

> Forms are eternal and unchanging, while objects continually change and shift. Although most men accept the objects of belief as 'really real', the philosopher knows better. To him, only the Forms are real, and anything below them on the scale of reality is bound to appear illusory and insignificant in comparison.[4]

Platonic theory of knowledge and existence can be found in the *Allegory of the Cave* in Book VII of *The Republic*. Existence in the natural world is compared to mere shadows on the wall of a cave. What cast these shadows, the "ultimate reality," is the idea, or universal, from which the imperfect shadows are derived. The natural world, like the shadows, exists; but it is the universal ideas like the source of the shadows that is "really" real.

DISAGREEMENT OF DEFINITION OF ABSTRACTION

Aristotle is in complete disagreement with Plato on this point. Aristotle recognizes the existence of these universals, but they are not the primary being. He believes that these universals derive their existence only as abstractions and are consequently dependent upon the natural bodies.

> Aristotle insists that only the individual, the concrete whole which is form-in-matter, can truly be said to be primarily and in its own right. Essence may be separated from individually existing things in thought but never in reality. Universals can only be secondary substances.[5]

In Book Zeta of *Metaphysics*, Aristotle outlines his reasoning. His first reason is an indirect proof. The universal cannot be the primary being for all classified under it because all these objects are different things, i.e., no two are exactly the same. His second reason is that we derive the characteristics of a universal from the various concrete substances which share these characteristics. His third reason is that primary being must be *one*.

Take for example a man who *is* husband to one woman and *is* brother to another. The ideas of husband and brother are both inherent in this man. Then if the idea is the primary being, this man has a dual existence. This, Aristotle points out, is an obvious absurdity. This man is a unit; he is *one* man, not two. He can be a husband and brother but only on a secondary level. Primarily he is John Doe, one man; a microcosm in himself.

Aristotle goes on to cast doubt on the certainty of the existence of Ideas completely removed from individual objects. Since they are removed from our sense perception, we cannot prove their existence. Aristotle, however, believes that these Ideas, or pure forms, do exist. Unfortunately, it cannot be determined exactly what they are.

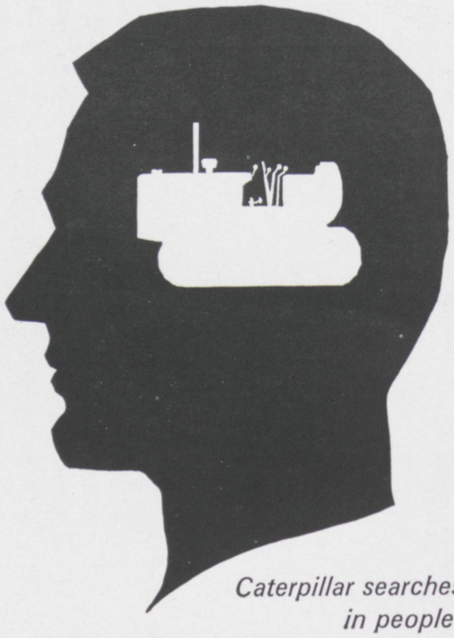
After studying the views of both Plato and Aristotle on reality, we are certainly better informed and somewhat enlightened, but we can not be completely satisfied. Both men provide excellent and convincing arguments, but they disagree on very important points. Who can say which is the correct philosophy?

CAN ULITMATE REALITY BE DETERMINED?

The problem of determining ultimate reality, *ousia*, is a very stimulating thought for a mature man. This is why men turn to philosophy in an attempt to answer such questions. Aristotle's and Plato's answers are logical and complete but not one hundred percent conclusive.

But then they could never be "the final word" in philosophy. It would be the death of philosophy if we took Aristotle and/or Plato as an infallible source. Each man throughout the ages becomes a philosopher to some degree when he ponders such cosmic issues. Man is, perhaps, best using his ability to think when he ponders ideas; and after all, thinking is the quality that distinguishes man from all else in the natural universe. When man thinks about such cosmic issues as ultimate reality and primary being, he is performing his highest human function.

1 Stocks, John L., *Aristotelianism*, p. 34.
2 Guthrie, W.K.C., *The Greek Philosophers*, p. 90.
3 *Ibid.*, p. 92.
4 Hagerty, T., *Review Notes and Study Guide to the Republic and the Dialogues of Plato*. p. 41.
5 Jancer, Barbara, *The Philosophy of Aristotle*, p. 73.



Caterpillar searches for uncommon quality...
in people and products.

What do you really know about Caterpillar?

You think of Caterpillar as a yellow machine, crawling along a muddy road. That's *all?* Think again.

Put 49,000 skilled people on that machine. Add 16 manufacturing plants, in *both* hemispheres, to your image.

Still not close enough.

Make that muddy road ten thousand roads. Mountainous. Jungle. Desert. Snow-covered. Base camp bouncers in Africa. Nation spanners in South America. Hill-and-dalers across Canada. Construction site hair-raisers, so far beyond the reach of cities that only the Cat representative bothers to describe them.

Not one yellow machine. Thousands. Not one Cat representative. An army of them. And a world-wide network of parts suppliers.

You've got to think of design. Manufacturing. Sales. And research—an average of $40 million a year, spent on research. (In 1964 it was $45 million). Big testing ground facilities. Technical centers, among the most modern in the world.

You've got to imagine engineers, too. Mechanical, chemical, industrial, metallurgical, agricultural, electrical, civil . . . every kind of engineer good schools produce. Caterpillar has an important position for all of them.

You might check into Caterpillar leadership in the world's business community. We stood 48th on the latest list of "500 largest manufacturers," and we're one of the top five exporters in the United States.

Ask your placement office for information on Caterpillar. Find out about some of the many contributions Cat research engineers have made in many more fields than earthmoving.

Got it? There's a scope of operations here that makes Caterpillar a good place to put your life. If you agree, get in touch. We certainly need what *you* have to offer!

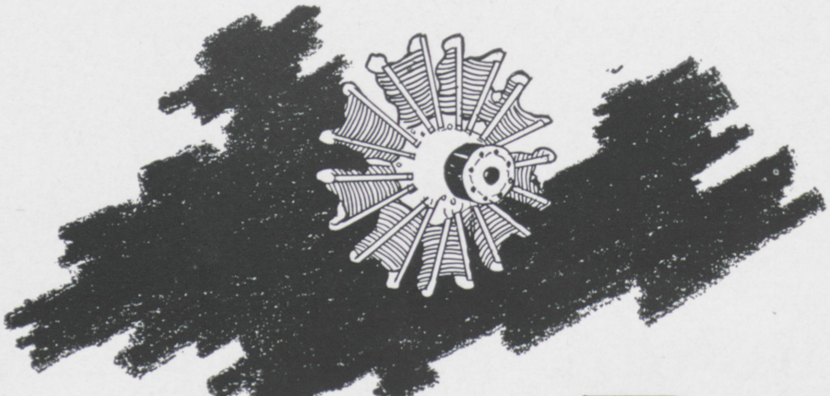
CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

"An Equal Opportunity Employer"

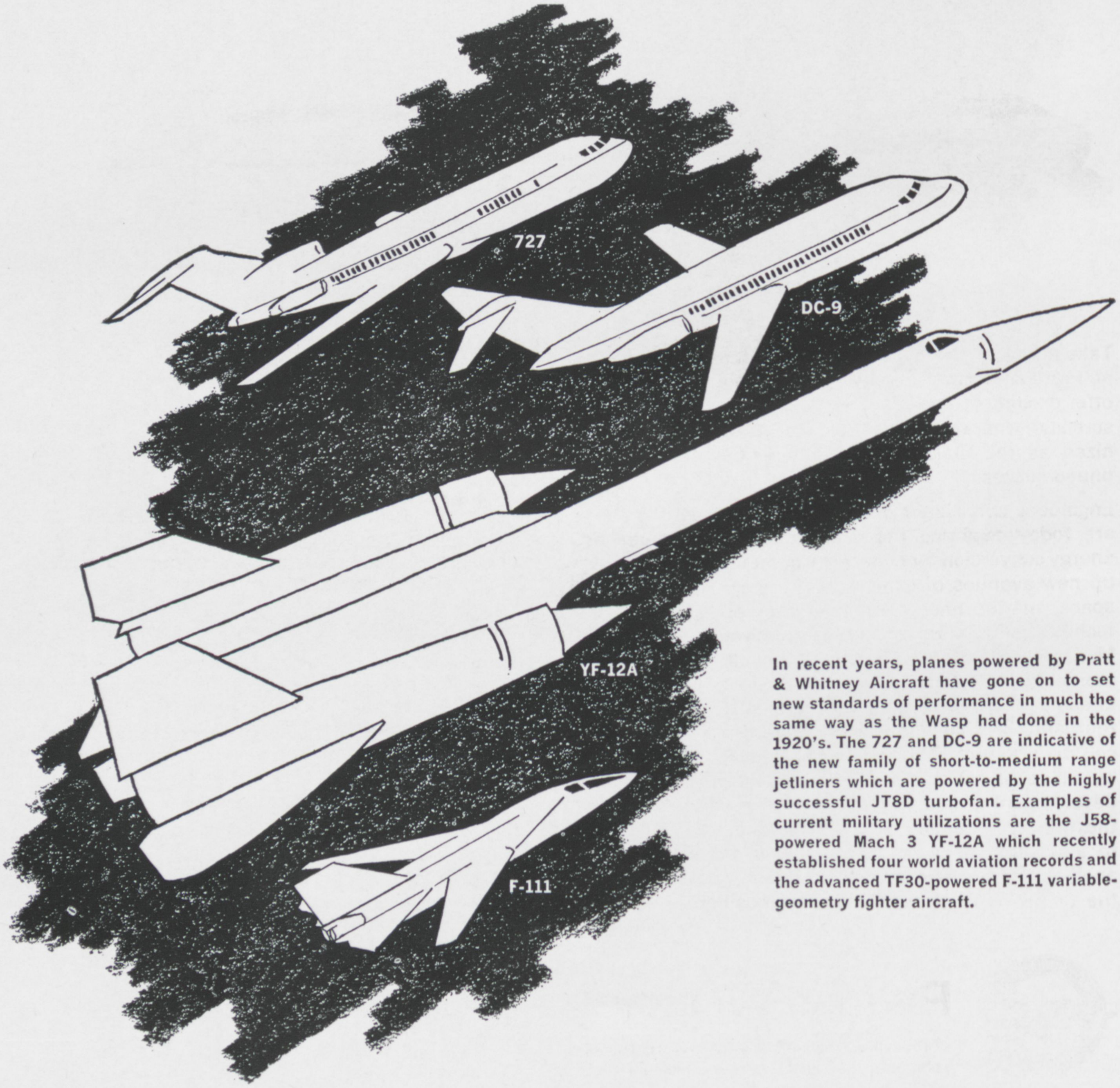
Caterpillar Tractor Co., General Offices, Peoria, Illinois • Caterpillar Americas Co., Peoria, Illinois • Caterpillar Overseas S.A., Geneva • Caterpillar of Australia Pty. Ltd., Melbourne • Caterpillar Brasil S.A., Sao Paulo • Caterpillar Tractor Co., Ltd., Glasgow • Caterpillar of Canada Ltd., Toronto • Caterpillar France S.A., Grenoble • Caterpillar (Africa) (Pty.) Ltd., Johannesburg • Caterpillar Mexicana S.A. de C.V., Monterrey • Caterpillar Mitsubishi Ltd., Tokyo, Japan • Tractor Engineers Ltd., Bombay, India

Past



The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

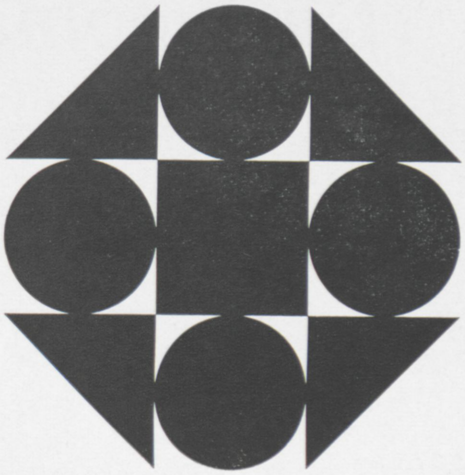
Present



In recent years, planes powered by Pratt & Whitney Aircraft have gone on to set new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative of the new family of short-to-medium range jetliners which are powered by the highly successful JT8D turbofan. Examples of current military utilizations are the J58-powered Mach 3 YF-12A which recently established four world aviation records and the advanced TF30-powered F-111 variable-geometry fighter aircraft.

MISS TECHNIC FOR MARCH

JOYCE HIZER



PHOTOS by GLENN RAQUE

MISS TECHNIC FOR MARCH

For March, the final month of winter, Joyce Hizer, a nineteen year old sweet talking, brown-eyed, brown haired freshman of I.S.U. from Logansport, radiates the coming of spring.

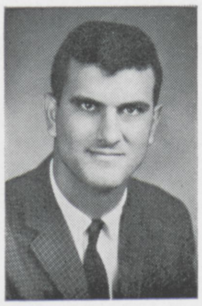
When time marches into summer, Joyce enjoys tennis and water sports like swimming and water skiing and keeps the March flower blossoming a trim posture of 35-23-35 at 5′ 4″. Until summer, pledgeship of Zeta Tau Alpha sorority and a prelaw curriculum should keep this dancing girl effervescent.

If you tango with Joyce, you had better be levelheaded; otherwise, you will not have a chance to plead your case or a leg on which to stand, besides being without a writ of habeas corpus.

Quantum Electronics

Part III

by Dr. H. A. Sabbagh



Dr. Sabbagh was born in Lafayette, Indiana, and lived there until graduation from Purdue University in 1958. In 1961 he returned to Purdue and received his doctorate in Electrical Engineering in 1964.

Wherein We Put Everything in (I) *and* (II) *Together and Get Some Interesting Results Pertaining to Parametric Amplifiers.*

1. *Introduction.*

Now that we have some background, we investigate the phenomena arising when an electromagnetic wave interacts with an acoustical wave. We will see that *parametric amplification* (i.e., amplification due to a varying system parameter) and *frequency conversion* result. Our presentation follows closely certain parts of A. Yariv, *"Quantum Theory for Parametric Interactions of Light and Hypersound," IEEE Journal of Quantum Electronics,* vol. QE-1, No. 1, April, 1965.

2. *Coupling of an EM Wave and an Acoustic Wave.*

As we showed in Part II, the Hamiltonian operator for the EM field is

(2-1)

$$H_{em} = \sum_{f=1}^{\infty} \hbar\omega_f A_f^+ A_f$$

and for the acoustic field

(2-2)

$$H_a = \sum_{k=-\infty}^{\infty} \hbar\omega_k B_k^+ B_k$$

The Hamiltonian for the combined system of electromagnetic and acoustic fields is the sum of (2-1), (2-2)

(2-3)

$$H_o = H_{em} + H_a$$

$$= \sum_f h\omega_f A_f^+ A_f + \sum_k h\omega_k B_k^+ B_k$$

In H_o there is displayed no term accounting for the interaction between the fields. If this were the only Hamiltonian of interest, life would be boring indeed: the EM field would go its own way, as would the acoustic field, and there would be no mating to produce an offspring.

Actually, of course, there is a coupling. In order to determine it, recall that acoustic vibration, since it represents material vibrations, will cause a change, $\delta\varepsilon$, in the dielectric constant of the material within the cavity. $\delta\varepsilon$ is related to the strain, $\frac{\partial q}{\partial x}$, of the mateiral by

(2-4)

$$\delta\varepsilon = -\gamma\frac{\partial q}{\partial x}$$

where γ is a constant (coefficient of electrostriction).

For a given field strength, E, the *perturbation in E,* will cause a *perturbation in stored energy* (and, hence, a *perturbation Hamiltonian,* H') given by

(2-5)

$$H' = \int \frac{\delta\varepsilon}{2}\bar{E}^2 dV$$

$$= -\frac{\gamma}{2}\int \frac{\partial q}{\partial x}\bar{E}^2 dV$$

H' supplies the necessary interaction between the EM field (represented by E) and the acoustic field (represented by $\frac{\partial q}{\partial x}$). By our previous expansion of q (x, t) in Part II, we have

(2-6)

$$\frac{\partial q}{\partial x} = \frac{1}{(AL)^{1/2}} \sum_k \frac{ik}{|k|}\left[\frac{h\omega_k}{2T}\right]^{1/2}$$

$$= \frac{1}{(AL)^{1/2}} \sum_k \frac{ik}{k}\left[\frac{h\omega_k}{2T}\right]^{1/2} \left[b_k^+ e^{ikx} - b_k e^{-ikx}\right]$$

When we substitute (2-6) into (2-5), use our previous expansion of the E field and insert quantum mechanical operators in place of the corresponding classical variables, we get for the pertrubation Hamiltonian operator

(2-7)

$$H'_{op} = \sum_f \sum_{f'} \sum_k \sigma_{ff'k} B_k (A_f^+ - A_f)(A_{f'}^+ - A_{f'}) + \sigma^*_{ff'k} B_k^+ (A_f^+ - A_f)(A_{f'}^+ - A_{f'})$$

where $\sigma_{ff'k}$ is a *coupling coefficient* given by

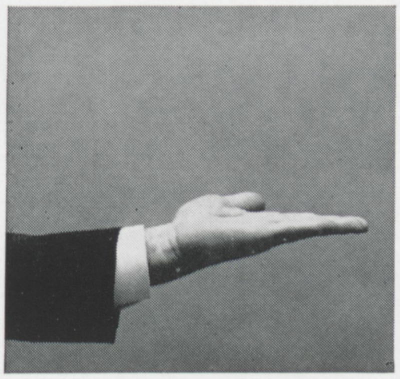
(2-8)

$$\sigma_{ff'k} = \frac{i\gamma}{4\varepsilon}\left[\frac{h^3}{2ALT}\right]^{1/2} (\omega_f \omega_{f'} \omega_k)^{1/2} \int_V e^{ikx} \bar{E}_f(\bar{r})\cdot\bar{E}_{f'}(\bar{r})\, dV$$

(*Continued on page* 25)

The Rain in Maine is Plainly

$$D = \frac{SNR}{SNR_o} = \frac{t/T_{SYS}}{t_o/T_{SYS_o}} = t_x \frac{T_{SYS_o}}{T_{SYS}} = \frac{\Delta - 1}{\Delta_o - 1}^{*}$$



Attention to detail is an old Bell System habit. Or maybe you call it thoroughness. Or follow-through.

Anyway, we attended to an interesting detail recently—the effect of rain on the microwave link between a communications satellite and our pioneer ground station antenna at Andover, Maine.

If we could but measure the rain's effect, we could improve the design of satellite ground stations. The question was how.

Well, you often have to take your laboratory tools where you find them, and in this case we found ours in Cassiopeia A, a strong and stable radio star that is always visible from Andover. We measured the noise power from Cassiopeia A during dry periods, and then measured the reduction during rainy periods. The result could be expressed as a formula and employed accurately in designing future ground stations.

The initial success of our Telstar® satellites proved the feasibility of communicating via space.

But it also opened the door—or the heavens—to a whole new technology which we are now busily exploring in every detail.

In space, on land or beneath the sea—wherever we operate—we go into things thoroughly.

Sometimes we know when <u>not</u> to come in out of the rain.

* * *

You may well find a rewarding career in the Bell System, where people find solutions to unusual problems. Bell System Companies are equal opportunity employers. Arrange for an on-campus interview through your Placement Office, or talk to a local Bell System Company.

*The definitions and derivation, plus further information on satellite transmission degradation due to rainfall, may be found in the Bell System Technical Journal, Vol. XLIV, No. 7, Sept., 1965, p. 1528, which is available in most scientific and engineering libraries.

Bell System
American Telephone & Telegraph
and Associated Companies

NASA'S HAMMER

In Norse mythology, Thor, god of thunder and defender in war possesses a magic hammer which he uses to perform incredible feats. Now NASA does not claim such an imaginative innovation, but through the services of modern science and technology at Advanced Kinetics Incorporated, a new version of that old metalworking tool has been developed.

The present use for the electromagnetic hammer is to remove distortion from weld abrasions on space vehicles. The new hammer offers the advantages of a minimum of moving parts and friction in applying a fairly uniformly controlled pressure without a die. However in its present limitations, the electromagnetic hammer is confined to metalworking on small areas and drastic distortion is beyond the range of the model.

The proper abstraction for the system is not as easy as it might appear. A. K. says that a general solution for the design of a electromagnetic hammer is not yet available, but experimentation has shown the following general trends:

Increasing parameter	Causes deflection to
Coil diameter	Increase
Number of wire turns in coil	Increase
Energy stored in discharge unit	Increase
Distance between coil and workpiece	Decrease
Material strength	Decrease
Material thickness	Decrease
Material resistance	Decrease

Since the material to be deformed must be considered as part of the total system, its characteristics can materially change the amount of deformation for a given amount of stored energy. Therefore a precise solution would require answers to at least two problems: (1) magnetic field distribution of the coil including effects of the workpiece and (2) mechanical behavior of the workpiece under various field distributions.

A typical electromagnetic hammer consists of a conductor spirally wound on a glass fabric insulation encased in a special epoxy resin. This unit in turn is mounted in a holder which positions the coil with respect to the work surface and absorbs the recoil of the hammering operation.

The energy system for the prototypes with variation in coil and inductance sizes is the power source, capacitors for storing energy, switches, transmission lines, and the magnetic coil. This capacitor technique has the ability to deliver an extremely large quantities of power into a relatively small span of time. However such a great energy discharge require a strong power supply and a unique transfer circuit. The resulting recoil from the discharge is cushioned by a pneumatic air cylinder.

Thus from Thor to Jules Verne and beyond, may be the day of the need for an electromagnetic hammer is to pass away. Perhaps in the near future energy fields will control the shape of metals as dies do now. As a portion of the National Aeronautics and Space Act of 1958 reads:

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

QUANTUM ELECTRONICS

(Continued from page 22)

The total Hamiltonian operator is

(2-9)

$$H_{Top} = H_o + H'_{op}$$

H_{top} *couples the acoustic and electromagnetic modes.*

3. *Interaction of Three Modes.*

Let us proceed to investigate the interaction of only three modes (there are an infinite number appearing in (2-9)). We designate one EM mode to be an input, or *pump* mode and refer to it by the subscript p. It is usually an intense field. The second EM mode is the *idler* mode, labeled i. The third mode is an acoustic mode which we call the *signal* mode and designate it with an s. Thus, we replace the subscripts l, l', and k by u, i, and s, respectively.

The three-mode Hamiltonian becomes

(3-1)

$$H_{Top} = h\omega_p A_p^+ A_p + h\omega_i A_i^+ A_i + h\omega_s B_s^+ B_s + \sigma B_s (A_p^+ - A_p)(A_i^+ - A_i) + \sigma B_s^+ (A_i^+ - A_i)(A_p^+ - A_p)$$

The first two terms on the right are the two EM modes; the third is the acoustic mode, and the last two, with the coupling coefficient, ó, are the interaction terms.

The Heisenberg equations of motion for the operators are

(3-2) (a)

$$\frac{dA_p^+}{dt} = \frac{1}{ih}\left[A_p, H_{Top}\right]$$

$$= i\omega_p A_p^+ - \frac{i}{h}\sigma B_s (A_i^+ - A_i) - \frac{i\sigma^*}{h} B_s^+ (A_i^+ - A_i)$$

(b)

$$\frac{dA_i^+}{dt} = i\omega_i A_i^+ - \frac{i\sigma}{h} B_s (A_p^+ - A_p) - \frac{i\sigma^*}{h} B_s^+ (A_p^+ - A_p)$$

(c)

$$\frac{dB_s^+}{dt} = i\omega_s B_s^+ + \frac{i\sigma}{h}(A_p^+ - A_p)(A_i^+ - A_i)$$

(d)

$$\frac{dA_p}{dt} = -i\omega_p A_p - \frac{i\sigma}{h} B_s (A_i^+ - A_i) - \frac{i\sigma}{h} B_s^+ (A_i^+ - A_i)$$

(e)

$$\frac{dA_i}{dt} = -i\omega_i A_i - \frac{i\sigma}{h} B_s (A_p^+ - A_p) - \frac{i\sigma^*}{h} B_s^+ (A_p^+ - A_p)$$

(f)

$$\frac{dB_s}{dt} = -i\omega_s B_s - \frac{i\sigma}{h}(A_p^+ - A_p)(A_i^+ - A_i)$$

Note that if ó = O the modes would all be uncoupled, i.e., the six differential equations for the mode operators would be independent of each other. These equations form a non-linear system because of the products of operators appearing in the right-hand sides.

A tremendous simplification results when we use the fact that the pump mode is intense. This means that there are a large number of pump photons present: so many, in fact, that the pump behaves classically. We may set, therefore,

(3-3)

$$A_p^+ - A_p = i\left[\frac{\varepsilon}{2h\omega_p}\right]^{1/2} E_{po}\left(e^{i\omega_p t} + e^{-i\omega_p t}\right)$$

where E_{po} is the amplitude of the pump field.

4. *Parametric Amplification and Oscillation*

Let us now consider what happens when the three modes satisfy the frequently condition $w_p = w_i + w_s$. Because of the energy-frequency relation $E = hw$, we may think of an idler photon colliding with a signal phonon to produce a pump photon whose energy is the sum of the other two.

When we substitute (3-3) into (3-2) (b) and (f) and retain only terms oscillation with frequency w_i and $-w_s$, respectively, we get

(4-1) (a)

$$\frac{dA_i^+}{dt} = i\omega_i A_i^+ - i\eta e^{i\omega_p t} B_s$$

(b)

$$\frac{dB_s}{dt} = -i\omega_s B_s + i\eta e^{-i\omega_p t} A_i^+$$

where η is a new coupling constant that may be taken to be real. The equations for A_i and B_s+ are obtained from (4-1) by complex conjugation of scalars and replacement of operators by their adjoints.

The solutions of (4-1) are easily found to be

(4-2) (a)

$$A_i^+(t) = e^{i\omega_i t}\left(A_{io}^+ \cosh\eta t - iB_{so}\sinh\eta t\right)$$

(b)

$$B_s(t) = e^{-i\omega_s t}\left(B_{so}\cosh\eta t + iA_{io}^+\sinh\eta t\right)$$

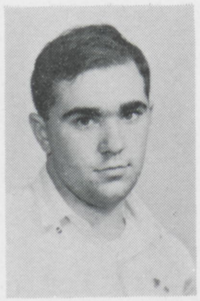
where the arbitrary constant operators satisfy

(Continued on page 28)

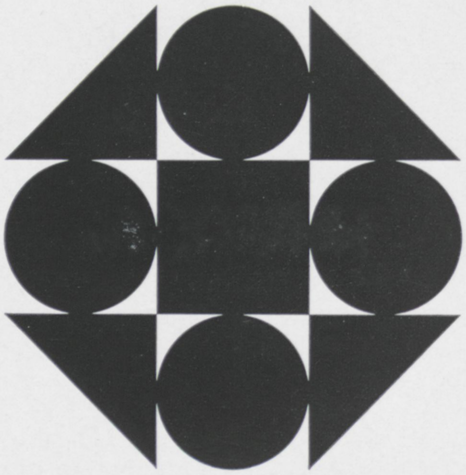
SPORTS

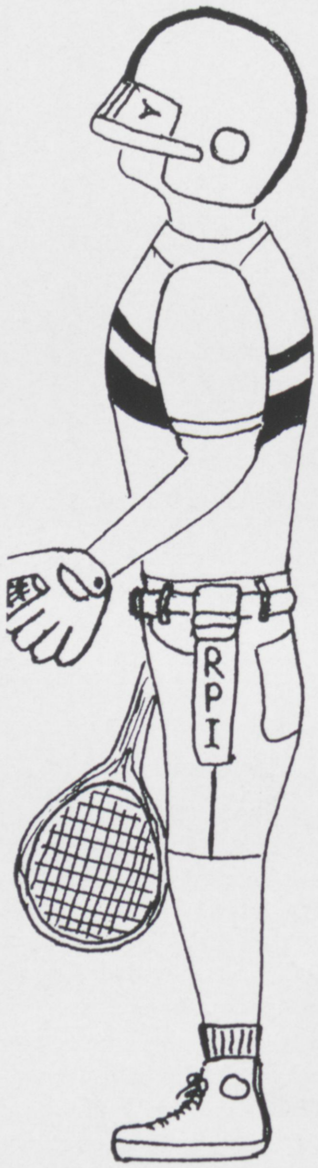
THE NEW IMAGE

by DON RILEY



The author of The New Image is Don R. Riley, a sophomore majoring in electrical engineering from Akron, Ohio. Don is a member of Lambda Chi Alpha fraternity, active in the Glee Club, and a veteran of the football team.





by Samoluk

The fall months of school in 1958 brought happy shouts to the Rose Poly campus. That year, the football team had risen to the occasion for eight straight games and emerged undefeated.

But the shouts quickly died. As the years progressed, the challenge of athletic competition offered little to those who were interested. Spirit and drive were lacking for those who did play. The attitude towards sports at Rose snowballed to low depths. And for the next eight years, every athletic team at Rose finished each season on the short end of victory.

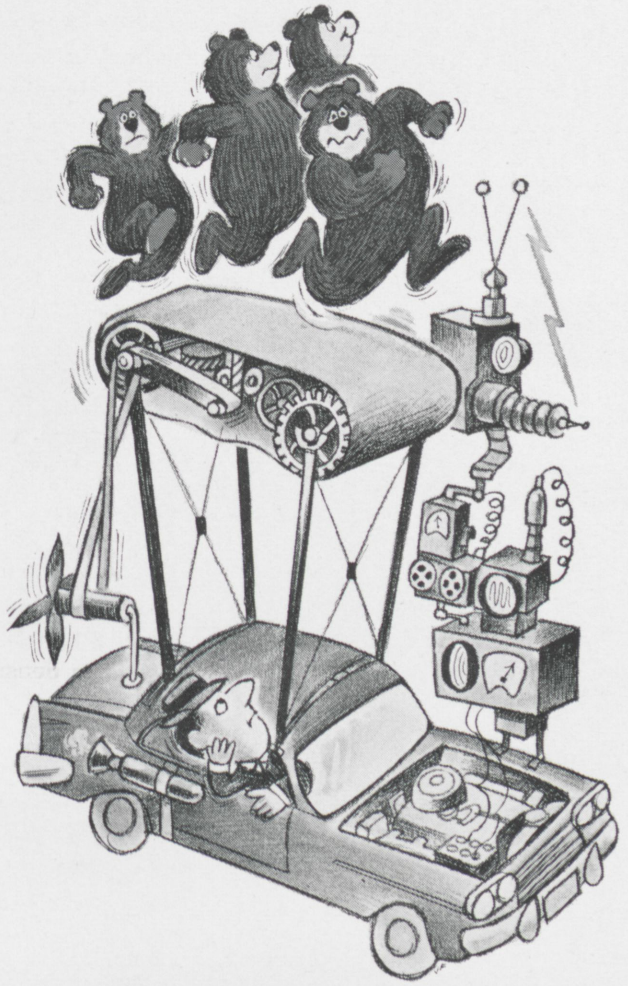
The attitude had become a crisis by 1964 when John Mutchner was appointed Athletic Director at Rose. The challenge he faced was foreboding, yet Coach Mutchner was willing to give his effort to turn the tide of apathy for sports. Since that time, athletic teams have ended seasons with higher won-loss percentages than during the bleak eight years since 1958. In 1965, the drought ended. The baseball team emerged from a thirteen game season with the first winning season for a Rose athletic team in eight years. Several weeks later, the golf team "holed out" a conference championship. This year, two teams have already triumphed in winning seasons. The sports future looks exceptionally bright, where once, Rose coaches had trouble suiting up enough men for athletic contests.

Yet with the future looking bright, much remains to be done to complete this transition and give Rose a new image in the Prarie College Conference. And so, I offer two challenges.

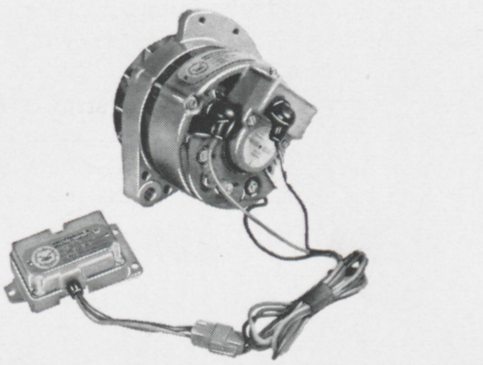
First, I speak to the Student Body. Spectator participation is a vital contributing factor to the spirit of a team. Large crowds arouse in each team member a spirit of competition. He wants to play well to let the crowd know they are needed. Rose spectator participation is improving but leaves much to be desired. Better participation in the stands will encourage teams to play with the spirit and determination needed to win. But it has to be the spectators causing a team to win, and not a winning team causing better crowds.

Second, I offer a challenge to Coach Mutchner. In order to have a well-rounded intercollegiate sports program, conditions must be equally good for all sports. Conditions are quickly improving, but there exists a basic inequality for several sports.

The new sports image at Rose has been given the needed spark to make this image glimmer. It needs to burn.



Hitch it to a herd of grizzlies . . .



. . . or feed it a Motorola alternator system*

THE PROBLEM: HOW DO YOU GIVE YOUR CAR BATTERY THE ENERGY OF A GRIZZLY BEAR — UPHILL, DOWNHILL, OR JUST TO GET GOING?

There was a time when engineering an alternator system was an impracticality. Most everyone in the business tried it — no one could successfully mass produce the automotive diode — the key to the system. Finally, Motorola engineers made the breakthrough — alternator systems are committing hapless generators to the museum showcase.

Today, alternator systems are designed for automotive, industrial, and marine use.

This sort of engineering sophistication is producing automotive electronic equipment to do things for the car that are impractical to accomplish mechanically.

Transistor ignition systems and electronic tachometers, hour meters for trucks and stereo tape decks, all-in-one air conditioning and heat control systems — these are a few of the projects currently in motion with Motorola automotive engineers.

The car radio? Sure. Motorola makes that too. Paul Galvin mass produced the first ones in 1929 . . . to start a little business.

*An electronic system that maintains a consistent, reliable energy supply for the car's electrical equipment.

TRUST THIS EMSIGNIA WHEREVER YOU FIND IT

MOTOROLA

QUANTUM

(Continued from page 25)

(4-3) (a)

$$\left[A_{io}, A^+_{io}\right] = \left[B_{so}, B^+_{so}\right] = 1$$

(b)

$$\left[A_{io}, B_{so}\right] = \left[A^+_{io}, B^+_{so}\right]$$

$$= \left[A_{io}, B^+_{so}\right] = \left[A^+_{io}, B_{so}\right]$$

$$= 0$$

Because we are interested in the time evolution of the signal phonon (quanta) number, we must calculate $B_s +$, B_s, the phonon number operator. From (4-2) (b) this turns out to be

(4-4)

$$B^+_s B_s(t) = B^+_{so} B_{so} \cosh^2 \eta t$$

$$+ (1 + A^+_{io} A_{io}) \sinh^2 \eta t$$

$$+ \frac{i}{2} \sinh 2\eta t$$

$$(B^+_{so} A^+_{io} - A_{io} B_{so})$$

where we have used (4-3) (a) in the second term on the right.

We take as the initial state Ψ_0 of the system that one having $^{n}i_{0}$ idler photons and $^{m}s_{0}$ signal phonons. Ψ_0 satisfies, therefore,

(4-5)

$$(B^+_{so} B_{so} + A^+_{io} A_{io}) \psi_0$$

$$= (n_{so} + n_{io}) \psi_0$$

The expected value (or average number) of signal phonons at time t is given by

(4-6)

$$n_s(t) = \langle B^+_s B_s(t) \psi_0 | \psi_0 \rangle$$

$$= n_{so} \cosh^2 \eta t$$

$$+ (1 + n_{io}) \sinh^2 \eta t$$

From this result we see that the number of signal quanta increases with time. Thus, we have an amplifier or oscillator, depending on how we get our initial phonons and/or photons. Note, in this respect, that even if the initial supply of these quanta is zero we still get a build-up of amount

(4-7)

$$n_s(t) = \sinh^2 \eta t$$

This term is equivalent to a fundamental quantum noise arising from the "zero-point" field fluctuations. It is a form of spontaneous emission and stems from the commutation relation (4-3) (a). These commutation relations are distinctly quantum mechanical and do not appear classically. Thus, there is a fundamental limiting sensitivity in amplifying devices which has no classical analogue. This fact is of importance in quantum electronics.

5. *Frequency Conversion*

We assume, now, that a phonon of frequency w_s "collides" with a photon of frequency w_p to produce a new photon of frequency $w_i = w_s + w_p$.

Upon substitution of (3-3) into (3-2) (b), (c) and retaining terms oscillating with frequency w_i and w_s, respectively, we obtain for the equations of motion for the frequency converter

(5-1) (a)

$$\frac{dA^+_i}{dt} = i\omega_i A^+_i + i\eta e^{i\omega_p t} B^+_s$$

(b)

$$\frac{dB^+_s}{dt} = i\omega_s B^+_s + i\eta e^{-i\omega_p t} A^+_i$$

The solutions are

(5-2) (a)

$$A^+_i(t) = e^{i\omega_i t}(A^+_{io} \cos \eta t$$

$$+ i B^+_{so} \sin \eta t)$$

(b)

$$B^+_s(t) = e^{i\omega_s t}(B^+_{so} \cos \eta t$$

$$+ i A^+_{io} \sin \eta t)$$

Hence, the average number of quanta present is

(5-3) (a)

$$n_s(t) = n_{so} \cos^2 \eta t$$

$$+ n_{io} \sin^2 \eta t$$

(b)

$$n_i(t) = n_{io} \cos^2 \eta t$$

$$+ n_{so} \sin^2 \eta t$$

Observe that now we do not build up an initial supply of quanta but "swap" them back-and-forth between the idler and signal modes. Note also that the frequency converter does not emit spontaneously. These are some of the obvious fundamental differences between a frequency converter and parametric amplifier.

INTERIOR OF EARTH

(*Continued from page* 10)

denser material nearer the center. The inhomogeneity with respect to the depth may be determined from the measurement of the moment of inertia as found from nutation factors. The expected moment of inertia if the density were a linear function of the depth would be:

$$I_a = .4\, Ma^2 \qquad 2.1$$

where M is the mass of the earth and a is the radius. The observed value is:

$$I_a = .3335\, Ma^2 \qquad 2.2$$

This shows a trend toward a greater than linear increase in density with depth. As an approximation of the trend, the relation $p = 12.19 - 16.71r^2 + 7.82r^4$ has been caculated under no other assumptions than the form of the equation. While this does not give a true form of the density, it furnishes workers in the field a rough guide to the trend the density follows.

INNER CORE

The inner core is thought to be the densist part of the earth, with densities ranging from 16.8 to 17.2 gram / cm^3. There is some evidence that this is solid in that from certain amplitudes of some of the seismic waves in some of the shadow zones are not what they would be if the inner core were not solid. In passing, it should be noted that evidence for the existence of the inner core comes mainly from some shadow zone of seismic disturbances, or area on the earth which do not experience nearly as great amplitudes as nearer areas. The depth of the inner core is thought to be about 5100 km. below the surface of the earth. This is so remote, and activity occurring in it would be almost completely masked by the effects of the other layers, it is almost a wonder we know anything about it.

OUTERCORE

We know a little more about the structure of the outer core. The density is considerably different from that of the inner core and there is a sharp change at the common boundry layer. The density of the outer core varies from about 9 to 11 gram/cm^3. The outer core is probably liquid. This is inferred from the fact that is apparently cannot support shear waves. Some objection has been raised to this argument by supposing the shear waves were absorbed in the outer core. With this in mind, a number of workers have shown that the outer core must be liquid from the observed values of internal tides. (2) The composition of the cores was once thought to be iron or iron nickel. If this were true, the density would be far too high to fit the observed values. It has been thought lately that the cores are of about the same composition as the mantle but in a different state. (2) This would account for the density and the core. This material is probably of and olivinic nature. The depth of the outer core has been determined to be about 2900 km. below the surface.

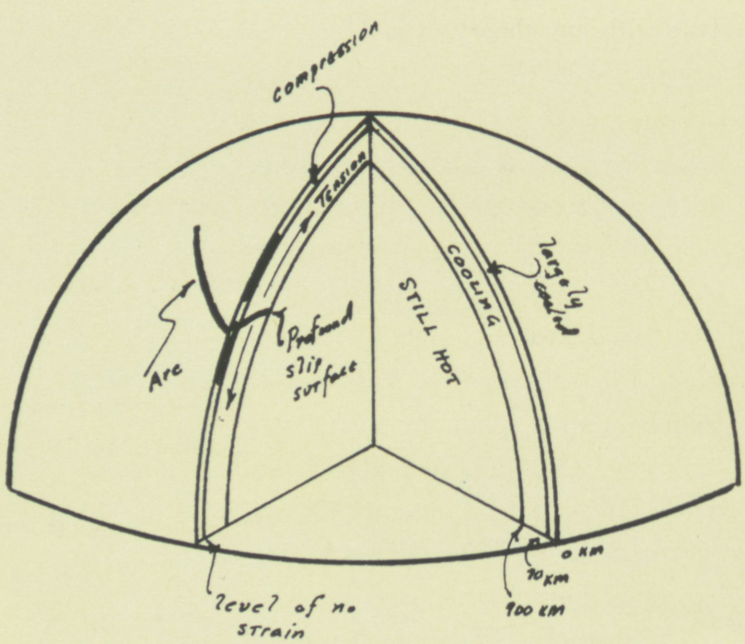


Fig. 3.

Shear relations in the upper part of the interior of the Earth. From Kuiper p. 172.

MANTLE

The mantle consists of all the material between the core and the base of the crust. The density of the mantle ranges from about 3 to 5 grams/cm^3. The material, from conjectures derived from the study of the bulk, shear and other moduli and the density of various rocks under high pressures, is thought to be some form of silicate, probably, olivine. It is thought to be rather homogeneous but there is evidence that there is a discontinuity occurring between the depths of about 300 and 500 km. This is the so called 20 degree discontinuity and is apparently the result of an increase of the velocity of P waves at that depth. One possible cause could be the change of state of the olivine from a rhombic to a cubic crystalline form. (2) This is also in the region of greatest tension. (2) The depth of the mantle varies from place to place, usually from about 8 km. under the oceans to 30 km under the continents. The boundary between the crust and the mantle is the Mohorovicic discontinuity. The actual nature of this discontinuity is not yet known.

EARTH'S CRUST

The crust itself, while the thinnest region of the interior of the earth, is also the best known and hence presents the most complicated view to the observer. There are two major divisions of the crust: the ocean basins and the continents. The ocean basins are composed mostly of basaltic, or basic rocks. The continents are composed mostly of less dense granitic, or acidic rocks. It is presently thought that the continents are "floating" on a basement of basaltic material. Almost all geological processes (i.e., weathering and formation by orogeny) occur in the crust.

One thing that should be mentioned about the crust is the theory of floating continents. As mentioned earlier, the continents are thought to be resting on the basaltic rock foundation. According to some authors (2), under long time action, the apparently solid rocks will react as fluids. A common example of this is glass. Look at the glass in a new window and compare it to the glass in window that has been in the same place for a number of years. The older window will be thicker at the bottom, due to the action of glass as a fluid under a small, long duration force. In a similar manner. it is thought that there are long term currents in the upper mantle. These are supposed to be convection currents and at places of upwelling and down welling, there is considerable folding of the crust. Associated with the currents, is the motion of the continents. It is conjectured that the continents are moved by these convection currents and that a one time were part of a primordial continent, the so called gondwanaland. Some evidence of this comes from the coastal lines of Africa and South America, and the apparent continuation of various fault lines in lands separated by an ocean basin but otherwise adjacent. There are, however, some rather major difficulties associated with this theory. As Dr. Betty Bunce of Wood Hole Oceanographic Institute mentioned during a lecture in the summer of 1965, there is a theory that the red sea is only a rift between Africa and Asia, but the petrology of the area seems to bely this notion, as the structures of the rocks on the opposite sides of the sea are not quite compatible. Evidence in favor of the theory comes from the mid-oceanic ridges and the heat flows found there. (1)

This, then is the general structure of the earth. Heat flow has not been considered, nor has the magnetic field. In detail they are too complex to present in such an elementary paper as this, in general, they do not tell much about the actual structure of the earth. It should be noted that the magnetic field is very important from the fact that it gives an indication of the dynamic processes deep within the earth. A deep study into the effects of the magnetic field might lead to a detailed knowledge of the motions within the core. Also a study of the heat flow and vulcanism may give rise to a deeper understanding of the mechanisms of deep faulting and energy dissipation of seismic shocks.

One last note about the theory of the structure of the earth. This theory is nice, but should not be taken to seriously, i.e., to the point where one believes this is the truth and there can be no departure from it. As is true with any theory, it is good only in that it can predict the structure of and event. If it fails there, then it is not a good theory. If it does not fail, then it is good until a better one can be found. Until we can actually reach the center of the earth, we will never be able to prove any theory absolutely. I do not know whether we will ever be able to reach the deeper parts of the earth, but until we do, all theories must accepted with a grain of salt.

[1] Heezen, "The Rift in the Ocean Floor", Sci Am. Vol. 203, No. 4, Oct. '60, pp. 198-110

[2] Kuiper (ed), *The Earth as a Planet*, University of Chicago Press, Chicago, 1954

[3] Press, "Resonant Vibrations of the Earth", Sci. Am., Vol. 213, No. 5, Nov. '65, pp. 28-37

tion. This gives different angular velocities at different distances from the sun. The total motion will be a turbulent motion superimposed upon a Kepler rotation.

So the question which now perplexes us is: Which pattern of motion will cause the least dissipation of energy by viscosity. The picture of Weizsacher is one of very little dissapation of energy.

Weizsacker built such a system of eddies on the circumference of a circle and then drew another circle around these and built another set, etc. This brought on his famous "bean-shaped" eddies, shown above in fig. 1.

Now the question of where do the condensations begin arises. The sense of the rotation of the solar nebula is direct. However, it is found that the epicycle eddies rotate in a retrograde sense in the rotating frame. So the circle on which consecutive eddies touch each other will develop "roller-bearing" type eddies, and these rotate in the direct sense. These "roller bearings" are the places most likely for condensation to begin. Soon these condensations grow to the place where they exert a gravitational pull on the surrounding particles, thereby further inducing more condensation. This process is only halted by depletion of the nebula [4]

The main critics to Weizsacker's theory have brought up the point that there is no reason to assume that the eddies formed will take the nice, symmetrical pattern as was postulated under the conditions envisioned. Ter Haar has also shown that the explanation offered by Weizsacker for the concentration of the mass in the sun and the concentration of the angular momentum outside in the planets is also untenable. [5]

KUIPER'S THEORY

An attempt to rescue this theory from its dire straits was made by Kuiper. He applied the Kolmogorov's spectral laws of turbulence to the initial solar nebula to obtain some distribution, rather than the highly artificial one of Weizsacker. The distribution which he arrived at is shown above in figure 2. [6]

As a further rejection of part of Weizsacker's theory, Kuiper does not keep the proposition of the "roller bearing" eddies as being the source of planetary condensations. He proves that the liftime of these eddies is very short, approximately equal to 0.01 the lifetime of the larger eddies, or less than one day. Also he found that the temperature inside these secondary vortices was very high. Because of these high temperatures and the transient character of these vortices, the secondary eddies appear less suitable to the formation of planetary condensations than do the primary vortices.

From the preceding arguments there appears to be no alternative than to postulate the condensation of planets from the primary vortices. We can see from examination of the laws of planetary condensations that the thing needed most in the formation of planets is time.

We find that there do not exist any eddies with densities high enough which have a long enough lifetime to condense out planets. However, it is found that under certain conditions the self-gravitation of the eddy cloud might be strong enough to hold it together for a sufficient time to allow planetary condensation to proceed.[7] If at a distance r from the sun the density of material is greater than the Roche density, given by

$$(8)\quad P = \frac{6M}{pr^3}$$

where M is the mass of the sun, the cloud becomes gravitationally stable[8] and planetary condensation can continue unhapered.[9] Using these ideas Kuiper found that the entire rotating disk would be broken up into separate spheres of action. These primeval condensations, according to his calculations, had all about the same mass. This presented a problem because it is known that every planet has a different mass. Again the theory was rescued by introducing a completely new concept. This was the idea that various proto-planets, in consebuence of the physical processes associated with condensation and sedimentation, condense into the planets varying proportions of their original material—from 10 per cent for Jupiter to 0.01 per cent for Mercury. The explanation for the satellites of the planets followed this line very carefully[30]

ALFVEN'S THEORY

Another new (relatively speaking) revival of the Kant-Laplace hypothesis is the electromagnetic model of Alfven. Alfven's theory begins with the condensing out of an embryo sun from the interstellar gas cloud. This embryo sun has accumulated about half the present solar mass and is distended to about the present extent of the solar system. The other half of the material was spread throughout a gaseous envelope surrounding the embryo and extending to a distance of about 0.1 light year.

The condensation of the sun, thereby giving it a preponderance in mass, caused the atoms to begin to fall toward the sun. However, the falling atoms are stripped of their electrons in their rapid descent, thereby ionizing them. At a particular distance from the sun the electromagnetic repulsion halts the movement toward the sun. The sun's magnetic field exercises a much stronger force of the atoms than does the gravitational field.

This gives the conclusion that once the clouds are ionized, the motions of the atoms are governed almost wholly by the electromagnetic forces.

Now atoms of different elements require different conditions to be ionized. We know that Helium is the most difficult to ionize. Therefore it falls farthest before being stopped. Alfven calls this the A-cloud. The next elements in difficulty to ionize (hydrogen, oxygen, and nitrogen) form the B-cloud. In the same manner the C-cloud and the D-cloud are formed. In other words, because of differences in voltages and temperatures required to ionize the various elements, the different chemical constituents of the initial cloud separate out. Alfven claims that rather than each group being chemically pure, the main groups just mentioned make up the most abundant elements and the other elements take the form of the trace elements.

Alfven shows that the B-cloud stopped in the region of the terrestrial planets (Mercury, Venus, Earth and Mars), the C-cloud stopped at the distance of Saturn, Jupiter, and Neptune, and the D-cloud halted outside Neptune. This is a very ingenious method of separating the chemical compositions of the planets as being different. In most theories it had to be just stuck in. Now to account for the odd angular momentum distrubtion in the solar system, Alfven invokes a process called acceleration. This is based on the magneto-hydrodynamic law which states; If there is a difference in the angular velocity of materials situated along a magnetic line of force, magneto-hydrodynamic effects will be produced and the result will be a transfer of rotation or angular momentum.[33]

The Interaction Theories:

I. PLANETESIMAL THEORY

Chamberlin and Moulton, around 1900, brought forth one of the first interaction theories of the origin of the solar system. This theory has been dubbed *The Planetesimal Theory*. These two saw that the sun is constantly in a state of eruption. The fountains of matter sometimes reach a height of hundreds of thousands of miles above the solar surface. So this theory postulates that once when the sun was in one of its major eruptions a star passed nearby and extended these eruptions into the form of two long arms, making the sun look like a spiral nebula. Ejections of matter solidified, thereby forming planetesimals. The matter ejected at one eruption formed the planets. Each big eruption was accompanied by a lot of little eruptions which formed the satellites of the planets. An investigation by Jeans in 1916 indicated that the effects of a passing star, however, were not what the two originators of the theory thought them to be.[34]

JEAN'S DYNAMIC TIDAL THEORY

Jeans said that the interaction took place between two stars passing very close together. Using S and S′ as the two stars, with R being their distance apart, Jeans found that S remains stable until it assumed the shape of a prolate spheroid with eccentricity $e = 0.8826$. At this point R is given by

$$(9) \quad R = 2.198 \left(\frac{m'}{m} \right)^{1/3} r_o$$

where r^o is the radius of the undisturbed sun. As S′ approaches closer, S begins to break up. The shape of the sun continues to be a spheroid until the eccentricity becomes 0.9477. A third harmonic displacement supervents and a waist is formed on the spheroid which deepens gradually and finally splits in two. But as this is happening other displacements represented by the fourth, fifth, etc. harmonics become unstable in turn and form waists. These are the results if the motions of the two stars is slow enough that the equilibrium theory of tides can be used.

If the motion of the two stars is much faster different effects arise. We must add up all of the instantaneous impulses to S by the passage of S′. If the total does not suffice to elongate to spheroid to an eccentricity greater than 0.8826, the tides will just recede back into the sun. If they do add up to enough, however, the instability goes in the manner described before. Jeans found the closest distance of safe approach to be

$$(10) \quad R^2 = \frac{\delta^{1/2} m'}{0.675 \pi p^{1/2}},$$ where p is the density of S, supposedly uniform.

If the value $v^2 = \delta\ (m+m')R$ is given to v, equation (10) can be written as:

$$(11) \quad R = 2.10 \left(\frac{m'}{m+m'} \right)^{1/3} r_o$$

The velocity v^2 which was assumed is impossibly small for the encounter of two stars. It turns out that the value of R necessary for break-up is less than 84 percent of that given by equation (11).[35]

This tidal theory runs into trouble almost immediately upon subjection to a quantitative test. The angular momentum distribution and the regularity of the spacing of the planets present glaring examples.[36]

JEFFREY'S THEORY

To attempt to save this theory, Jeffreys offered an actual grazing collision between the sun and a passing star.[37] It must be realized that such collisions, or for that matter, any close passing of two stars is about as likely to occur as two solitary Arabs on the Sahara meeting each other in the course of their random wanderings.[38] Jeffreys showed that, by taking into account the viscosity of the matter removed from the sun, the proper rotations would occur. However, the angular momenum of the planets would still only be approximately one-tenth of its actual value.[39] This is because dynamical considerations give that it would be utterly impossible to get a planet to move even at Mercury's present distance, let alone Neptune or Pluto's distance.[40]

RUSSELL-LYTTLETON THEORY

These difficulties led to the adoption of a binary-star origin for the solar system. In the suggestion of Russell, Lyttleton developed a theory which included an interaction, or possibly a collision with the companion star, situated most probably in the approximate position of the great planets. According to Lyttleton, this companion star would be hit by another star, is speeded up, and breaks away.[41]

This theory again runs into difficulties when it tries to explain the vast distances separating the planets. According to Lyttleton's theory the planets must necessarily have been formed in a narrow belt of distance close to the original distance from the sun of the companion. We know, however, that the planets are spread far and wide.[42]

HOYLE'S SUPERNOVA THEORY

Again the call arose for a doctor to mend the ailing Lyttleton theory. This time it was the illustrious Fred Hoyle, originator of be "Universe according to Hoyle", who answered the ring. He postulated the "supernova theory". He said that the companion star became a supernova through its gradual evolution. Suddenly it exploded throwing tremendous amounts of matter flying through space at a prodigious rate. Only a small degree of asymmetry of the explosion is necessary to send the companion recoiling away into space also. The sun needed to capture only a small wisp of matter flung away to have enough to manufacture all the planets. When the sun does capture this matter if forms into a ring of matter rotating around the sun at approximately the same distance of the sun's companion. As it cools it flattens into an annular ring which stretches all the way from the sun to perhaps the orbit of Neptune.

The growth of the planets would be a process of accumulation of particles. Colliding particles would form larger particles; these larger particles would exert gravitational attractions on their neighboring particles and would finally grow into the form of huge planets. This theory does have the advantage of being able to manufacture the heavy elements of which the planets are made without recourse to some "hocus-pocus".[43]

If is difficult to understand, however, how any of the material blown out of the companion star by the supernova explosion could ever be captured by the sun. This material would be at an extremely high temperature. A calculation by Spitzer has shown that the factor favoring the escape of material from the sun's gravitational influence by its own radiation pressure is about 100. The radiation pressure of the supernova material at such high temperature is far too great to allow the matter to be captured by the sun.[4]

4

SCHMIDT'S THEORY

As has been seen each of these encounters between stars has presented the theoriticians with tremendous difficulties. But there are other things in the sky with which the sun could interact. One of these is the intergalactic gas clouds. The interaction between these two forms the basic of the theory of Otto Schmidt. Schmidt suggests that as the sun winds its way through the universe it "plows" through one of the many intergalactic gas clouds which are found in space, just floating around doing nothing. As the sun passes through the cloud it drags a portion of it into its gravitational field. Already difficulties are found with Schmidt's theory. If the sun were moving then as fast as it is now, this type of interaction would be very unlikely.

Despite the difficulties in the beginning, the theory from that point on bears repetition. Schmidt felt that the theories of catastrophic planetary origin were quite impossible due simply to the severity of the conditions necessary to carry out such processes. He thought that the slow development of the planets could have come about in one of two ways: (1) they could have originated at the same time and from the same single mass or, (2) they could have originated from preexisting interstellar matter after the sun had developed. Schmidt rejects (1) because of the peculiar distribution of angular momentum in the solar system. So he said the matter for the planets must have come from the interstellar gas.

Now that the sun has captured this gas cloud, it was rotating around the sun. This rotation arose because of its initial rotation around the galactic center. Its capture turned a portion of this rotation around the sun, the result being the flatening of the cloud. The dust particles of the cloud began to precipitate toward the equitorial plane of the cloud, after being separated out from the gas by solar radiation. The mutual gravitational attractions of these dust specks would be increased because of the decreased distance between them. The result would be a collection of asteroid type bodies of various sizes and shapes. Some of the embryos grew faster than others and began to gather together the "trash" formed by the smaller bodies. From this mechanism the planets soon appeared.

From this theory the orbital regularities and the distribution of the angular momentum present no difficulties for explanation. But for the explanation of the Titus-Bode law, i.e.,

(12) $r_n = 0.4 + 0.3\ (2)\ n\text{-}1$, Schmidt must resort to some fancy footwork. He comes up with the relationship

(13) $R_n{}^{1/2} = p + an$, but he was forced to use two different sets of constants p and q to make the data fit, one for the four inner planets and another set for the five outer planets. Schmidt rescues this discrepancy by noting the differences in the planetary compositions for the four inner planets as compared to the five outer ones. Beyond the asteroid belt solar heat is practically zero. But inside it, the warmth is considerable. For anything to stick to the inner planets it must be made of some stony or metal material. The temperature of the outer giant planets is so low, however, that volatile materials are literally frozen on them. This difference in composition justifies Schmidt's use of two different constants. This same factor also serves to explain how the low mass-high density condition exists for the inner planets, while for the outer planets it reads high mass-low density.[45]

Although the initial difficulties to Schmidt's theory are tremendous, this theory does break up the monotony of the repetitious catastrophic ideas and presents a new approach. Urey, in 1953, showed by a study of the present abundance of volatile elements that the earth's surface was unlikely to have ever been exposed to a temperature greater than the boiling point of water.[46] So possibly we should not abandon Schmidt's ideas without further investigation.

Summary:

As a rule scientists try to observe a system and from these observations deduce the regularities associated with it. This has been done with the solar system but the yield is small. There are only four of these prized regularities which have been observed. It is these four which each theory discussed above has tried to explain. They are:

(1) The orbital regularities — all the planets revolve the sun in nearly circular orbits which lie more or less in the same plane. The rotation of the planets about their own axis is always in the same direction as their orbital revolutions. Moreover, the planets lie practically in the equatorial plane of the sun—about 6° off.

(2) The distances of the planets from the sun follow the Titus-Bode law of

$$r_n = 0.4 + 0.3\ (2)\ n\text{-}1$$

(3) The masses of the four inner planets are low and the densities high, but those of the Jovian planets are reversed; the mass is high and the density low.

(4) Almost the entire angular momentum is gathered in the planets and their satellites, while the sun possesses practically all of the mass. The sun's mass makes up 99 percent of the total while it possesses only about two percent of the angular momentum.[47]

In each of the proceeding theories it was found that one or two of these points were covered well by the theory but the remainder acted as quite a thorn in the side of calling any one of them successful. For example, Schmidt's theory does an admirable job in accounting for features (1) an d (4) but its explanation of (2) and (3) is very shaky.

The same holds true for the other theories which have been discussed. One big stumbling block has been this peculiar distribution of angular momentum. This distribution is referred to as being peculiar because one most generally associates the place where most of the mass is concentrated with the place where the majority of the angular momentum arises. In the case of the solar system this is reversed.

And just as characteristic of each theory as the stumbling block is the "magic" hypothesis. This is usually in the form of recourse to another subject matter applied in the problem being discussed. The "acceleration" of Alfven, the dual set of values for the Schmidt version of the Titus-Bode law, the Roche density and gravitational stability of the Kuiper theory, are only examples of this clever gimmic to overcome the hurdles thrown up in the path of a prospective theory on the origin of the solar system.

[1] Jagjit Singh, *Great Ideas and Theories of Modern Cosmology,* Dover Publications, New York, c. 1961, p. 201

[2] James Jeans, *Astronomy and Cosmogany,* Dover Publications, New York, c. 1961, pp. 396-398

[3] *Great Ideas and Theories of Modern Cosmology,* p. 204

[4] J. A. Hynek, editor, *Astrophysics, a* Topical Symposium, McGraw Hill Book Co. New York, c. 1951, pp. 367-369

[5] *Great Ideas,* p. 225

[6] Op. cit., p. 226

[7] *Astrophysics,* pp. 375-379

[8] *Great Ideas,* p. 226

[9] *Astrophysics,* p. 378

[10] *Great Ideas* p. 227

[11] Harold C. Urey, *The Planets, their Origin and Development,* Yale University Press, New Haven, Conn., c. 1952 pp. 1-16

[12] *Great Ideas,* p. 227

[13] Op. cit., pp. 214-220

[14] *Astronomy and Cosmogany,* pp. 399-400

[15] *Op. cit.,* pp. 400-406

[16] *Great Ideas,* p. 205

[17] Op. cit., pp. 205-206

[18] Op. cit., p. 207

[19] Op. cit., p. 206

[20] R. A. Lyttleton, *Man's View of the Universe,* Little, Brown and Co., Boston, c. 1961 pp. 50-51

[21] Op. cit. p. 52

[22] *Great Ideas,* p. 207

[23] *Man's View of the Universe,* pp. 52-55

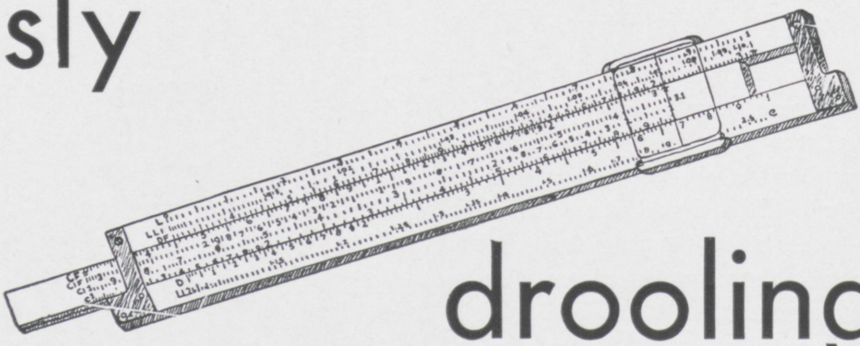
[24] *Great Ideas,* pp. 206-207

[25] Op. cit., pp. 208-212

[26] Ibid., p. 212

[27] Op. cit., pp. 202-205

sly droolings



Stolen by Chuck Risch, Jr. M.E.

Last month we gave you an excuse for obtaining certain classified data from your girl. Here are the essential equations so that you can put that data to good use. (to be used with the graph published last month)

$$NR = \frac{\text{Hips (in.)} \times \text{Bust (in.)}}{\text{Waist (in.)} \times 60}$$

$$NP = \frac{\text{Ring Size} \times \text{Head Diameter (in.)} \times \text{No. Teeth}}{\text{Shoe Size} \times \text{Wrist (in.)} \times \text{Grip (lbs.)} \times \text{No. Chins}}$$

$$NB = \frac{\text{Shoe Size} \times \text{Wrist (in.)} \times \text{Grip (lbs.)} \times \text{No. Chins}}{\text{No. Chins} \times 33{,}000}$$

An ROTC officer approached the young man in the neatly fitting olive green uniform and asked, "Who is the brigade commander?"

'I don't know," admitted the poor fellow.

"Haven't you ever gone on the drill field?"

"Nope."

"Don't you know enough to say 'sir' to an officer? What company are you in, anyway?"

"Me? I'm the Coca-Cola man."

* * *

ME: After you drink a lot. does your tongue burn?"

CE: "I don't know, I've never been drunk enough to light it."

* * *

Lady to police department: "Come quick. I just ran over an engineering student."

Police Department: "Sorry, lady, this is Sunday. You will have to wait till tomorrw to collect the bounty."

* * *

The admiral had made himself very unpopular and when he fell ill and had to go to the base hospital, everyone breathed a sigh of relief. The hospital did not improve his temper, however, and he made life miserable for the staff. One day, one of the orderlies put on a surgeon's mask and went into the admiral's room, picked up his chart and examined it very professionally. Then he advised the admiral that he would have to take his temperature and told him to roll over on his stomach. On no account was the admiral to turn over, and he promised to return to read the thermometer as quickly as possible. The admiral harumphed but did as he was told. About an hour later the floor nurse looked in to check on the admiral and found him still on his stomach. "What an earth are you doing, sir?" she inquired.

"What is the matter with you?" growled the admiral. "You've seen people having their temperature taken before."

"But admiral," she cried, "with a daffodil?"

Then there was the M.E. who stepped up to the bar very optimistically, and two hours later went away very misty optically.

* * *

Irritated Professor: "If there are any morons in this room, please stand up." A long silence, and a lone freshman rose.

Professor: "What, do you consider yourself a moron?"

Frosh: "Well, not exactly, sir, but I do hate to see you standing alone."

* * *

An elderly lady approached a small boy and asked: "Tell me, young man, do you have a fairy godfather?"

"No," replied the little boy, "but I have an uncle we're all a little suspicious of."

* * *

Then there was the surgeon who transplanted brains. One day a wealthy but not too bright man came in inquiring about the types of brains being offered.

'Well," the doctor said, 'we have lawyers at $10,000, doctors at $15,000, and civil engineers at $50,000.

Why does it cost more for a C.E. than a doctor, or a lawyer?"

"Well, for everyone it takes a pound of brains and do you realize how many civils it takes to get a pound of brains!"

* * *

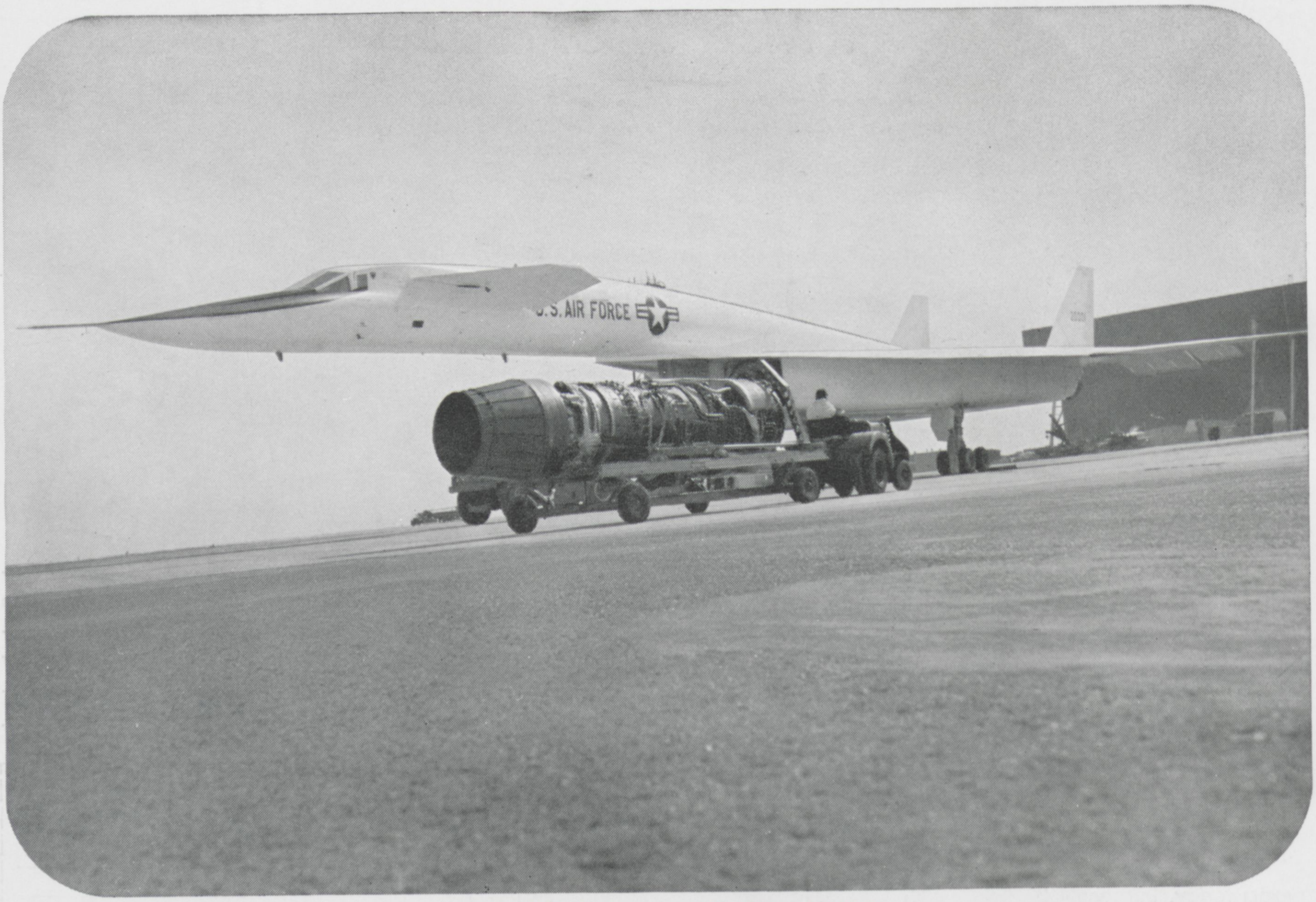
In addition to the S. A. T. and high school grades, Rose now has a new entrance exam. They send you to a magic show. If you sit there and take it all in, you pass. If you ask questions and try to figure it out, you can still come to Rose but you can't major in physics.

* * *

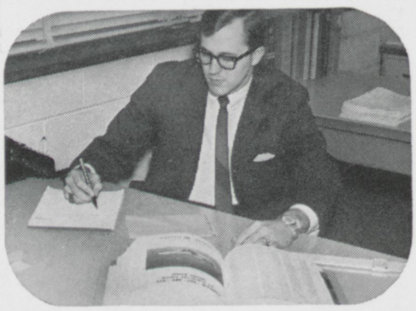
It's remarkable how much fun you can get laughing at the picture on your ID card before realizing that's what you really look like.

* * *

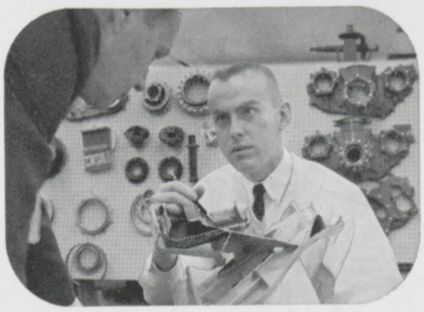
Now go back and read the rest of the magazine.



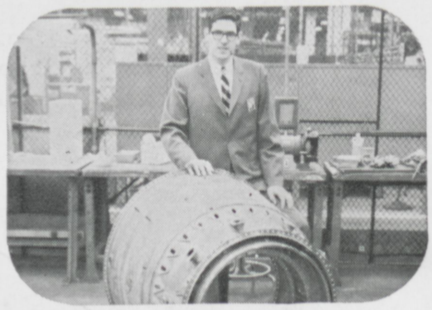
SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.



JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.



PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.



ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

Progress Is Our Most Important Product

GENERAL ELECTRIC